ELECTRICAL REVIEW
AND
INDUSTRIAL ENGINEER

Volume 80 **Chicago, February, 1922** *Number 2*

Absorbing Ideas
is one thing—
Using Them
is another

From my official stool as "Sponsor for the Average Reader" I might say a lot of things about the articles in this issue for most of them bring back experiences, some tough ones and some just half way, that might have been avoided if I had burned the candle a little later digging into such practical information as given by Mr. Whitcomb and Mr. Roe on pages 63 and 78 of this issue.

I sometimes wonder if we older fellows don't overlook a mighty big opportunity—yes, responsibility—in our contact with the younger ones who are just getting started. It's easy to get impatient with a beginner because he doesn't know some of the things that we have learned by years of experience; but in the long run that attitude does more harm than good. The better way is to sit down with him and put him on the right track for it is certain that if he doesn't know where he's going he will never get there. I would rather tell a fellow something he may know already than say nothing and miss a chance of telling him something he doesn't know and may be too proud to admit. A little wrinkle may be old stuff to us, but down at the other end of the shop there is somebody who has never heard of it, and could make good use of it. In reading these articles then, I suggest that you point out to your men some of the ways they can use the pointers and ideas in their own work. You can probably see a hundred ways to their ten for applying this information.

For instance, show your armature winders how to mount some of the useful Roe diagrams for reference at the winding bench. This can be done with a "passe partout" outfit. Simply take a stiff card and a piece of transparent celluloid, place the diagram between and paste the gummed strip around the outside edges. This will prevent dirt and grease from making the drawing hard to read.

In the January issue there was a useful table on induction motor troubles, their diagnosis and remedies. It is well worth posting on a board with a coat of shellac to keep it clean and hanging on the wall by the chief electrician's desk. I've seen the time when I would have given a lot for a guide of that sort.

Just start this practice of suggesting uses for the information this paper gives you and watch the men who get interested in it. They're the men to pick for superintendents and foremen later on.

Practical Pete

1879

1881

1881

1887

1893

1905

1906

1907

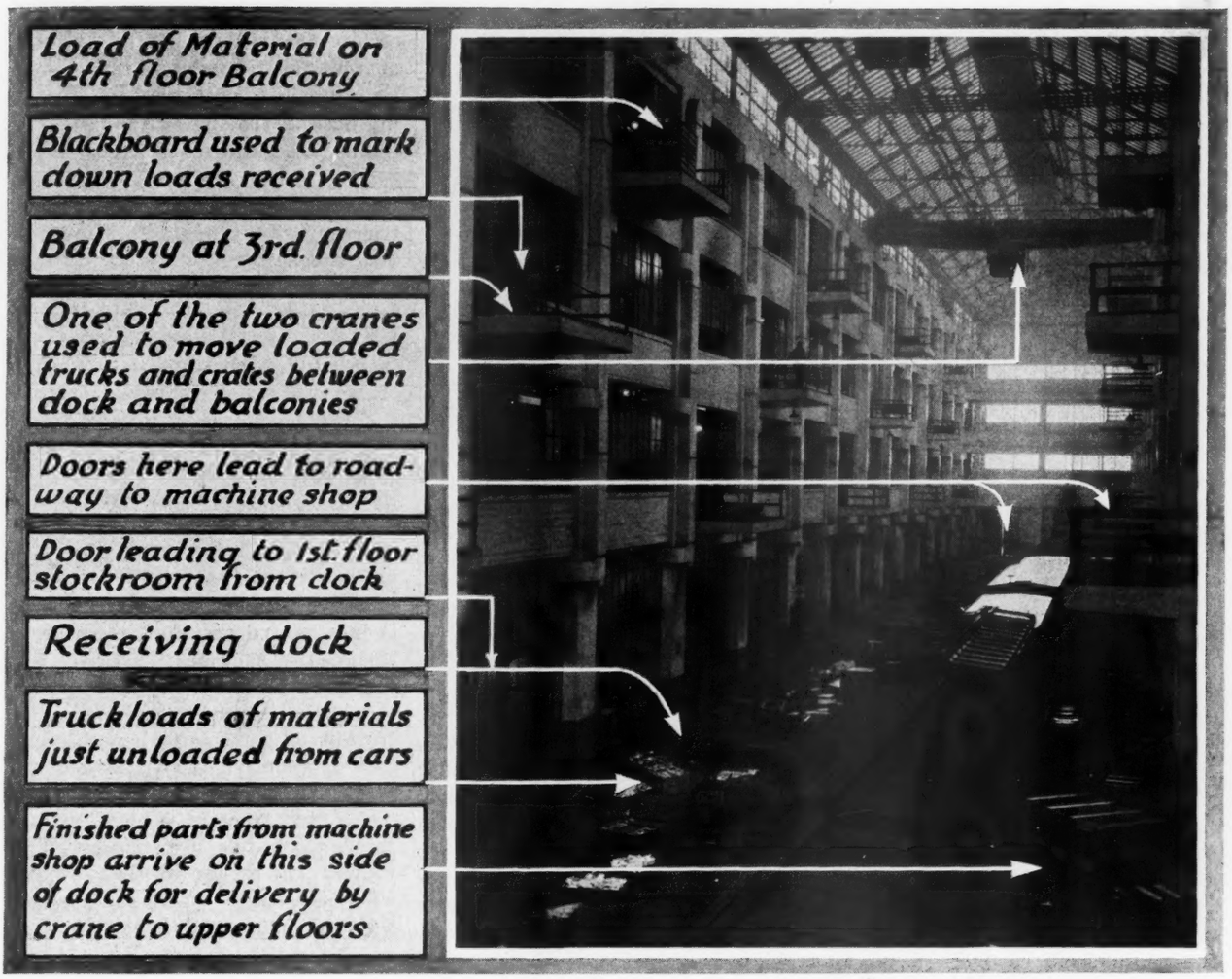
1911

The STORY *of the* INCANDESCENT LAMP *told in pictures*

Sir Humphrey Davy discovered in 1810 that thin strips of metal became white hot on passing a current of electricity through them, but no practical use was then made of this knowledge. In 1879 Edison developed the multiple circuit and made a lamp with a carbonized-thread filament. This lamp was publicly exhibited in December of that year. The first commercial lamps made in 1881 had a carbonized-bamboo filament, which was abandoned in 1893 for one of cellulose. In 1905 the Gem metallized-carbon filament lamp was brought out. Tantalum-filament lamps were introduced in 1906, but were soon displaced by the tungsten filament which is now used. About 1913 it was discovered that the efficiency of the tungsten lamp could be increased by filling the bulb with nitrogen or argon, instead of using a vacuum. This is the present practice.

1922

1913


Load of Material on 4th floor Balcony
Blackboard used to mark down loads received
Balcony at 3rd. floor
One of the two cranes used to move loaded trucks and crates between dock and balconies
Doors here lead to roadway to machine shop
Door leading to 1st. floor stockroom from dock
Receiving dock
Truckloads of materials just unloaded from cars
Finished parts from machine shop arrive on this side of dock for delivery by crane to upper floors

Here is an instance where

Plant Production has been Organized Around a Material-Handling Plan

RESULTS from making a plan and then working that plan are everywhere evident in the South Bend (Ind.) works of the Studebaker Corporation of America. The buildings and their equipment constitute a smooth working machine that receives many parts at one end and turns out a complete automobile at the other. The illustration above shows the sub-assembly building where material is received and distributed to the various departments.

ELIMINATION of hand labor to the greatest possible extent is the keynote of the material handling methods used in Plant No. 2 of the Studebaker Corporation of America, South Bend, Indiana, and to this end many ingenious plans and devices are used. Storage-battery tractors with an assortment of trailers, some of a standard design built for general use, with others designed for specific purposes, comprise a vital part of the entire transportation plan around which plant production is organized.

Materials and finished parts received by railroad are delivered in cars on railroad tracks running through the centers of the two main buildings. The receiving docks, one at either side of the receiving tracks, are at the level of the car floors, so that material may be moved to the first floor dock with the least possible effort. Materials and parts unloaded on this dock are checked in as to condition and quantity and are placed in the appropriate containers for movement into stock. This operation of loading into containers marks the beginning of the plant transportation system.

The receiving tracks and platforms, passing through the center of the main building are spanned by traveling cranes running on tracks mounted above the top (fourth) floor of the building. Gal-

These transportation pilots keep material moving in Studebaker Plant No. 2.

Thirteen men handle seven battery-operated tractors, motor truck and a passenger car used in plant transportation work. Two of the tractors run on regular schedules, the other four are assigned to special department duties. One machine not shown here is used for the handling of scrap materials.

leries project out over the receiving dock at various points along the second, third, and fourth floors, and serve as receiving platforms for the stockrooms located on these floors.

Types of Trucks Used on Receiving Dock

The containers into which received materials or parts are loaded on the first floor docks are in many cases a standard type of two-wheeled truck with a front rest and socket for the attachment of a third wheel. In other cases the containers are special, two-wheeled trucks with a similar front rest and third-wheel socket. For certain kinds of material the container is a box or special tray. Where boxes or special trays are used they are either set into a regular two-wheeled truck, described above, or placed on a flat-topped, two-wheeled truck with front attachment fittings for the third wheel. Thus, the various pieces and parts received by train are all loaded, after checking for quantity, into wheeled trucks. These loaded trucks are moved from the receiving platform to the various stock rooms, in most cases the trucks serving as stock storage bins until such time as the entire truck load is needed for use in production. Then the loaded truck is moved into the production department, where its contents may be required; frequently it is run up to the first machine on which process work is done on the particular part which the truck contains.

Equipment Used for Transporting Material

From this point on, materials are transported in a variety of standard and special-wheeled containers through the medium of special overhead conveyors, cranes, hoists, roller conveyors, chain conveyors, etc., each one of which is particularly suited to the task required of it. Finished or partly finished parts are moved by conveyors or on trucks into the inspection departments and into or out of the stock rooms as required. Stock rooms, in general, occupy the portion of the building next to the balconies, already mentioned, which overhang the receiving dock at the side of the receiving tracks. The loaded trucks on the receiving docks are moved by hand for short hauls, and in trains by tractor for long hauls, into the first floor stock rooms. When parts or materials are destined for stock rooms on the upper floors the loaded trucks are lifted in chain slings attached to the hooks of the traveling cranes and are deposited on the balconies opposite the store room where they belong. This leaves in most cases only a short haul by hand to the storage space where the load remains until needed for use in production.

Usually the point where the various parts in stock enter production is just beyond the stock room space assigned to such parts. Where this condition prevails the movement to the initial point in the production train is by hand, but where a longer haul is required the truck loads of parts are set out and picked up in trains by tractors which run on regular schedule over pre-arranged routes. The trucks are then dropped off at the points where the parts in the load enter production processes.

Typical carload of materials and parts ready for transfer to stock departments.

Automobile headlights, it will be noted, are left in their original cartons. Other items are loaded into wheeled trucks, and some small parts are left in bulk in boxes. The cartons and boxes are placed in trucks for transfer to stock.

All Handling Is Done by Battery-Driven Tractors

The various types of wheeled trucks in which the materials are transported into stock and through the plant are hauled, except for very short distances, by a fleet of seven, battery-driven tractors. The trans-

Loaded train enroute from machine shop to receiving dock.

Several different types of special trucks may be seen in this train. There are two cylinder trucks, one crank-shaft truck, one connecting rod truck, besides several standard box trucks. The endurance of the tractor is shown by the fact that the roadway was exceedingly slippery and this load was hauled near the end of a hard day's work in the snow.

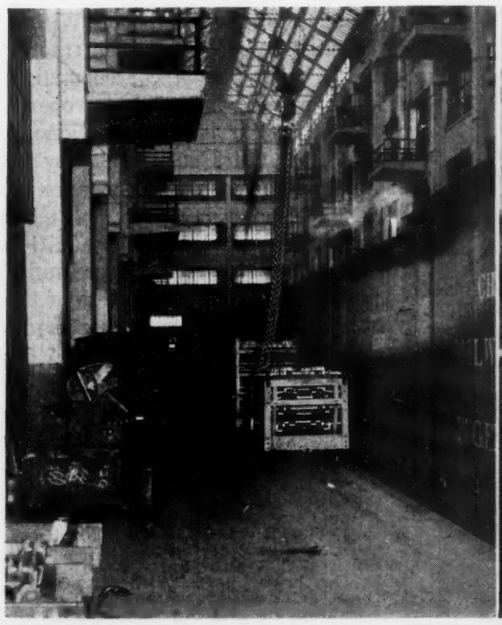
portation department also has one motor truck and one passenger car for general service, mostly outside of Plant No. 2. This equipment is handled by an operating force of twelve men working under a foreman of transportation. One man, designated as a "dispatcher," works under the transportation foreman, taking care of records, orders, reports and the handling of unexpected or unusual difficulties. The other men in the department, including seven tractor drivers and one helper, and three men assigned to the truck and passenger car, are under the jurisdiction of the dispatcher.

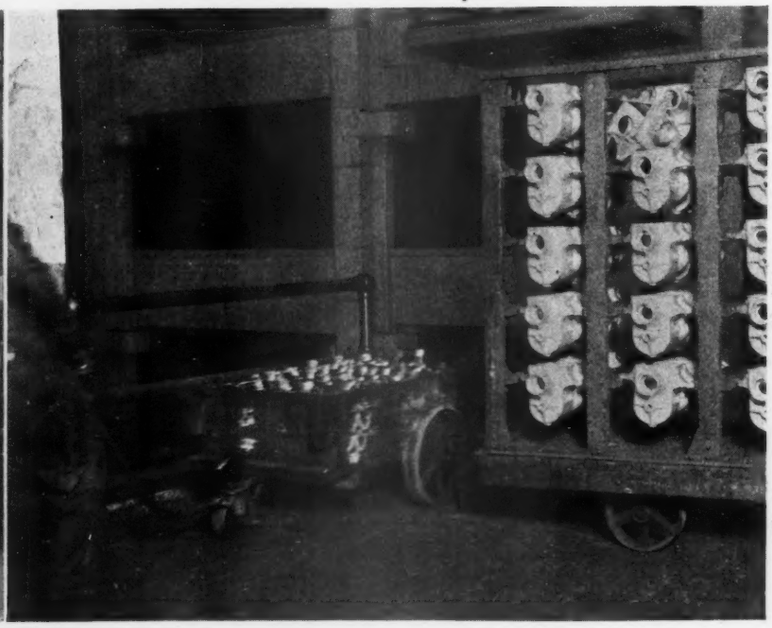
Special services are assigned to each of the seven tractors, so that the work may be carried on from day to day without conflict or confusion. Machine No. 1 is assigned to a regular route, making trips every 30 minutes. The duties assigned include the movement of finished materials from the inspection bay of the machine shop to the receiving dock and to other points on first floor of the sub-assembly building. Empty trucks are returned by the same machine for reloading in the inspection bay. The second machine, No. 2, is used to move rough stock from the forge shop and rough-stock room on the first floor of sub-assembly building to the machine shop counting station. Here the contents of the trucks is checked against the original count made at the time the material was loaded into the trucks, and is then passed on to process. This tractor makes a regular trip once every hour. Tractors No. 1 and No. 2 are checked at each end of their runs by a time clock stamp, the driver carrying a card on which the successive runs are recorded.

Machine No. 3 serves various sub-assembly divisions. It hauls finished motors to the motor stockroom on the second floor of the final assembly building, hauls front and rear axles from the third floor to the second floor of the final assembly

Picking up loaded trucks on the receiving dock for movement to an upper floor.

One crane is just lifting a truck off the floor, while the second crane is waiting with the chain sling at the side of a crank-shaft truck. Empty trucks at the side of the dock are waiting to be returned to the machine shop.





Moving a truck load of material placed on an upper floor balcony by crane.

The wheeled handle under the front of the truck is used only while the truck is being moved. A hook in the top of the wheel frame fits into a special fixture. When the wheel is disengaged the truck rests on an iron foot.

building and transports running boards, head lights, steering wheels and wiring assemblies to the final assembly stockroom. Passage from second to third floor is made over freight elevators, and passage between the assembly and final assembly buildings is by means of inclosed bridges at the various floor levels.

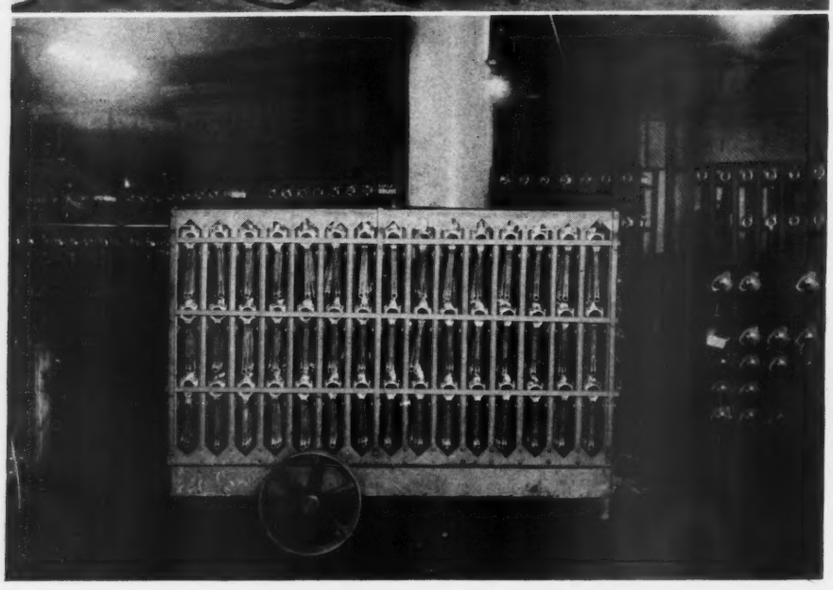
Machine No. 4 is assigned to miscellaneous service as directed by the dispatcher. However, it does have a specific assignment hauling oil, grease, and enamel from the oil storage room to various points, this service requiring about 2½ hours per day. Machine No. 5 picks up high-wheeled trailers delivered in the plant yard and moves them onto the receiving dock. These high-wheeled trailers carry trucks of running boards, crates of body frames, and other similar parts made in a separate plant about a block away.

One machine, No. 6, is assigned to duty in the stamping room, hauling dies, moving trucks of stock and finished material, and so on. Machine No. 7, the last of the fleet, is assigned to duty handling scrap materials. Scrap metal and cuttings is collected by conveyors and by sweeping and is dumped through an opening in the floor of the machine shop into waiting trucks. Tractor No. 7 picks up these trucks and hauls them to the scrap room. This truck has other duties, but all pertain to the removal of scrap material.

The general plan of assigning specific duties to each tractor has been found to serve the needs of this plant to the best advantage. With a fixed rate of production each tractor is called upon for a corresponding amount of work, and by properly distributing the assignments among the various units each one may be required to give a full measure of service without being called upon for excessive overloads. In addition to this, the men have an opportunity to gain an intimate knowledge of the requirements of the departments which they serve and plan ahead for transportation emergencies.

Rough-stock parts in storage on first floor of the sub-assembly building.

Small rough-stock parts are loaded into wheeled trucks which are stacked in piles to utilize space most effectively. The track of the crane which handles these trucks may be seen in the upper portion of the illustration. Identification tags on the trucks are clearly visible on those at the left.



Trucks and racks in a sub-assembly department.

The truck in the center is designed to handle finished connecting rods. After being matched in sets of six the connecting rods are placed in the upper part of the rack shown at the right; crank-shafts are placed in the lower part. A workman at the back removes the rods and crank-shafts and fits them together.

I Don't Like to Preach, But—

I always hate to hear anyone say, "Oh, that's good enough," for I'm pretty sure that he is simply trying to convince himself and the other fellow that a half-way job is just as good as the best that can be done. Now, I don't mean that a lot of time should be spent in doing things that aren't necessary; these are speedy times and often there isn't much room for pink ribbons and fine lace, but any job that is worth doing at all is worth doing *right*. And I know by experience that when you are inspecting or repairing electrical equipment or doing anything else, for that matter, the very best you can do is none to good. Study the suggestions of Mr. Whitcomb in his article on inspection and get the idea that your job is to prevent troubles, not to wait for a breakdown.

Practical Pete

UNINTERRUPTED operation and low maintenance costs of large steel mill drives depends upon the correct functioning of a large number of individual elements. The failure of any one may stop or damage a large part of the mill output. Attention to details is essential. Just what kind of attention is needed and how it can be organized into a definite maintenance schedule is outlined in this article.

Where to Look for

Things that Cause Trouble

in Reversing-Roll Electric Drives

By ARTHUR J. WHITCOMB

Electrical Department, Steel and Tube Company of America, Mark, Ind.

Replacing the contactor magnet coils on auxiliary control board.

This board controls the roll table working in connection with the blooming mill and its reversing main motor. Its equipment is subject to unusually severe service and requires constant attention to guard against the chances of an interruption of operation. Contacts and coils are replaced prior to failure whenever possible.

DURING the past fifteen years electrical drives, when applied to the main rolls of blooming, billet and plate mills, have shown a marked reduction in the cost of steel mill operation. Owing to the size and character of the electrical equipment required and the rough service which it must stand, adequate inspection and maintenance is an essential factor in economical operation and continuity of service.

The maintenance and inspection operations required for such large apparatus are many and varied. Probably one of the most important operations is that of cleaning, which is done with compressed air at 30 to 60-lbs. pressure. A water separator is used in the air line to remove the water from the air before it goes into the apparatus. Particular attention is paid to directing the air blast at different angles against the windings on revolving parts, since the combination of a greasy atmosphere and carbon dust causes a deposit on these parts that is difficult to remove. Collector rigging and slip rings are also thoroughly blown out. The carbon dust from the brushes will form a leakage path between the slip rings which may break down and cause a flashover on the rings when an attempt is made to start the motor. After being blown out, the insulation between the rings is brushed or wiped with a rag, and occasionally painted with an insulating varnish. At less frequent intervals, the reversing motor is opened and thoroughly cleaned.

MR. WHITCOMB takes up in this article the steps in maintenance practice that were outlined in a general way in his article that appeared on page 23 of the January issue of Electrical Review and Industrial Engineer. The "Maintenance Summary" schedule which accompanied that article shows the frequency with which the various maintenance operations are carried out for the large units discussed in this article.

Inspecting brushes in flywheel motor-generator set.

All brushes on main units are inspected regularly once a week and are thoroughly overhauled once every four weeks. In this illustration the inspector is holding up the brush spring with his left hand while removing the brush for inspection with his right hand. Brushes found to be chipped or broken are replaced with new ones having a full contact face, or are ground down where conditions permit. One defective brush may cause much trouble by overloading the remaining good ones.

The commutators and brushes of both the generator and the motor require careful and frequent inspection, for they must handle rapidly-varied and high-peak current values. The commutator is watched during regular operation, and any trouble that develops is diagnosed at once and steps are taken to remedy it at week-ends.

Commutator troubles manifest themselves in three ways: sparking, noise, and vibration. Sparking attracts immediate attention and investigation is made at once to determine whether it is caused by wrong spring tension on the brushes, brushes sticking in the holders and throwing excess load on the rest of the brushes, or dirt on the commutator. A stick or pencil is placed on a brush to detect vibration. If the brush vibrates, possibly a flat spot or high bar has developed on the commutator. If there is pin-fire, together with slight vibration, it is possible that the mica is high.

Commutators Are Ground With a Special Tool

When the machine is stopped for the week-end, a detailed investigation is made for commutator troubles. If the commutator has a high or low spot, it is ground. Grinding can best be accomplished by bolting some form of lathe-tool rest (special stone holders are now on the market) direct to a brush arm after the brushes have been removed. The stone is clamped to this tool rest and is slowly fed across the commutator. Commutator stones are usually classified as coarse, fine and extra fine, the fine stone being most suitable for this service. Light cuts are taken, otherwise the stone tends to spring away from the commutator at the high spots, and cut in at the lower spots. The speed at which the commutator is revolved depends on its condition and size, but in all cases the final cuts should be made at the regular operating speed. Since the stones are made of non-conducting material, the commutator, if on a motor, can be driven from its regular source of power. For final polishing, an extra fine stone is used, which may be placed in the tool rest or held in the hand.

If the commutator has high mica, it is undercut. This is done with special slotting files or short lengths of hacksaw blades held in suitable handles. For large commutators, such as shown in accompanying illustrations, a small power-driven revolving saw is more rapid and gives better service. After the mica has been cut about one-sixteenth inch below the surface, the commutator slots are beveled with a V-shaped file and any rough projections filed away. The slots are then cleaned with a wire bristle brush having bristles sufficiently limber not to scratch the commutator, yet stiff enough to clean all dust, stone grit and loose mica away from the slot.

Brushes Are Closely Inspected

All brushes are thoroughly inspected, each brush being removed from its holder for examination. If the brush binds in the holder, the

The Elements of a Reversing-Roll Electric Drive

[1]

REVERSING - ROLL electric drives are used on the main rolls of blooming, billet and plate mills, where fast reversing and variable speed is necessary. At the Mark (Ind.) plant of the Steel and Tube Company of America an Ilgner flywheel motor-generator is used to convert the alternating current received from the power house to the variable-voltage direct-current which is supplied to the reversing motor. Speed control of this motor is obtained by field control of the generator and motor fields.

[2]

UNITS of the reverse-drive equipment include: (1) a large induction motor; (2) a slip regulator for equalizing the input of the induction motor and thus allowing the flywheel to give up its stored energy during the load periods; (3) the direct-current generator which supplies the power to the reversing motor; (4) the exciters for the fields of the generator and motor; (5) the blower for supplying the cooling air for the reversing motor; and (6) the switchboards, control panels and drum controller for regulating the operation of the entire equipment.

[3]

AS to the size of the various units ordinarily employed; the induction motor ratings vary from 1,500 to 3,000 hp.; the flywheel usually weighs from 40 to 50 tons. The reversing motor has a peak-load capacity of 8,000 to 15,000 hp., while the generator must be of sufficient size to supply the power required by the motor.

latter is cleaned and the brush sandpapered enough to slide freely and yet fit snugly in the holder. The wearing face of the brush is examined for broken ends or edges, for pitting, and for ridges. If the brush ends are broken, they are sanded until a full surface is obtained, and, in any case, copper deposits and pits are sanded off. The shunts or pigtails are examined for loose connections, since loose pigtails quite often cause heating of the remaining brushes by throwing excess load on them. Brushes that fill only three-fourths to seven-eighths of the box of the brushholders are removed and replaced with new brushes. The storeroom maintains a stock of new brushes of the correct bevel, so that only a little sanding is necessary to seat them properly.

Sanding brushes is an important job, for the future behavior of the commutator depends to a great extent on the care taken in seating them. Brushes as furnished by the manufacturer have flat, beveled ends, and it is necessary to grind this flat surface to fit the curvature of the commutator before the brush is ready for use. This is done by placing the brush in the holder in which it is to be used and drawing strips of sandpaper beneath it, meanwhile maintaining a heavy spring tension on the brush. Coarse sandpaper is used at first, the finishing being done with a fine grade. The strip of sandpaper should be drawn in only one direction; namely, the direction in which the commutator revolves.

After the brushes have been properly seated, the spring tension is set at the required value, equal tension being given to all brushes. If much trouble is experienced in doing this, a small spring scale is used for adjusting. Springs should be set to give a pressure of 2 to 4 pounds per square inch of brush surface, depending upon the grade of brush and the condition of the commutator.

Correcting Ridged and Worn Slip Rings

Regular inspection is made of the condition of the slip rings and the slip-ring brushes. Most difficulties with slip rings arise from ridging and from wearing out of round, the remedy for which is grinding. Since most slip rings on main drive equipments are made of steel, grinding is best accomplished by using a power-driven grinding wheel. The slip rings should be revolved at a fair speed during grinding, but it is not necessary that the rings be run at normal speed. Where the slip rings are on the induction motor of a flywheel motor-generator set, the set is brought up to speed, the power cut off and the machine allowed to coast

Commutator grinding machine in place on brush holder support ready to start the operation.

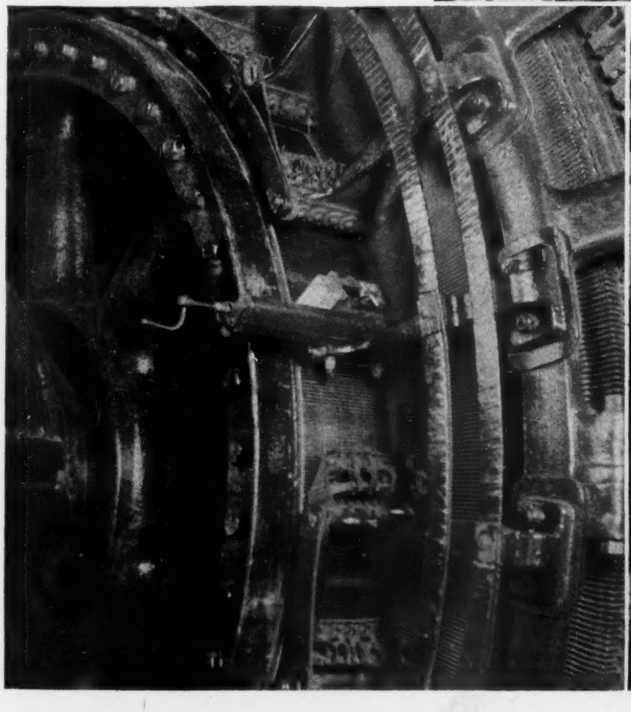
The grinding machine is bolted to a brush holder supporting arm after throwing back the two supporting links. The stones used for grinding are moved across the face of the commutator by means of the cross-feed screw at the end of the grinding machine, and are raised or lowered by another screw, the handle of which may be seen just above the stone support.

Grinding commutator on a 15,000-hp. reversing blooming mill motor.

With the motor rotating and the stone working on the face of the commutator it is necessary to keep a close watch on the grinding operation. The stone is moved gradually across the commutator as it turns in much the same manner that a lathe tool would be moved across the face of a piece of work. A very light cut is taken, and for finishing a fine stone should always be used.

Setting a commutator-grinding machine before starting the work.

The operator is shown here lowering the grinding stone, using his right hand to adjust the lowering screw. With his left hand he is moving the stone across the commutator face to see that a proper alignment has been made in setting the machine. Proper machine alignment is essential in order that the same depth of cut may be made on both the inside and outside edges of the commutator, otherwise the commutator would be finished in a conical shape instead of cylindrical.



while the actual grinding is taking place. Under such conditions, the flywheel will keep the motor running at a satisfactory speed for 20 or 30 minutes.

Inspecting Bearings

Careful and frequent inspection is given to all bearings during the normal operation of the apparatus. Oil rings are watched to see that they carry up a sufficient quantity of oil and that they run at their normal speed. Naturally, the temperature of the cooling water and the oil in the reservoir must be watched as well as the temperature of the bearing itself. This is especially true of the bearings on the flywheel motor-generator set when the power has been shut off and the set is coasting to rest. It takes from one to two hours for this set to come to rest, and at the lower speeds sometimes the rings do not carry up enough oil to maintain the oil film in the bearings. This is particularly true of the flywheel bearings. A case is known where the bearings ran cool for a week and were cool prior to shutting down, but before the set came to rest one of the bearings was burned out.

Bolts and nuts are all gone over regularly to see that they are tight. Bolts, such as those clamping the brush holders to the brush arm, the brush arms to the frame, the copper bus connections to the motor and generator, field connections, resistor and control connections, bolts that hold the field coils in place, and so on, are all important points to inspect and especially the bolts which hold in place the interpoles of the reversing motor. These interpoles are long and slim and are constantly subjected to a reversing side thrust. Since there is little bearing surface at the base of the interpole, the bolts often loosen slightly and break, thus releasing the interpole. If the interpole released happens to be on top of the motor, the armature may be badly scored. Cases are known where the interpoles have actually broken off the bolts and were released.

There are a few things which need to be done only two or three times a year; namely, measuring the air gaps, testing the overload trips, testing the insulation and painting the windings.

The most important air gap to be checked is that on the induction motor, but a record is made of all of them.

There is an over-speed trip on the motor-generator shaft. This is removed, mounted in a lathe and revolved at 10 per cent above the rated speed of the set to see that it trips properly.

Insulation resistance is measured just after a shutdown, while the machines are still hot. If the megger gives a satisfactory reading, twice normal voltage may be applied between the winding and ground by means of a "shooting box" or step-up transformer. Steel-mill practice does not approve of giving this high-voltage test as a regular maintenance operation; so it is done only after a rewinding job. An insulation failure on routine test often means rewinding the machine. This entails a serious mill delay, and it is believed that it is better to have the machine fail in service than to have it fail on test during regular inspection. Money spent on rewinding after service failure can be satisfactorily explained, but a rewinding operation after a test failure is a hard thing to justify.

All windings are painted at least twice a year. The cheapest way to do this is to spray on an air-drying varnish. It is hardly necessary to say that the windings must be clean before varnishing.

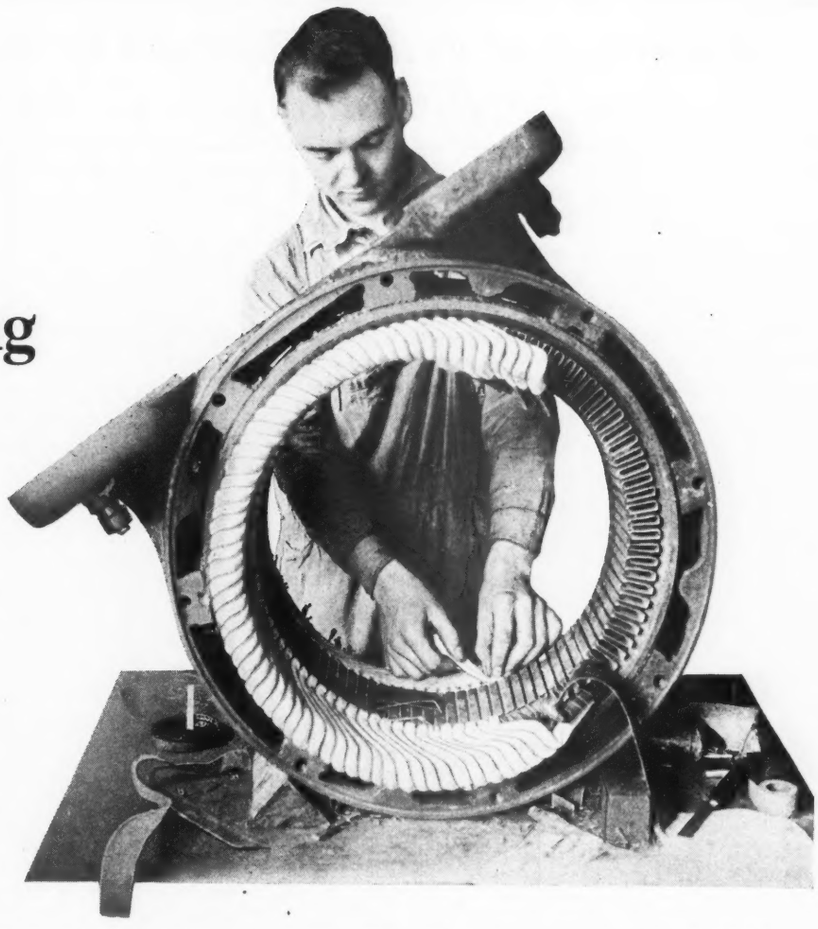
Inspecting closed ends of reversing blooming mill main motor.

This machine is of the double armature type, the space between the ends of the two armatures being enclosed by plates mounted on a supporting frame. The plates have been removed and the inspector is shown examining the condition of the field coils and their connections. While the machine is opened up an examination is also made of the inside ends of the armature coils to see if they show signs of overheating or loosening.

Maintenance of Control Equipment

Slip regulators are overhauled about four times a year, this overhauling consisting of (1) draining out the electrolyte; (2) taking off the jars or tubs; (3) removing and cleaning all the electrodes; (4) removing all sediment from the tank and tubs (*Continued on page 103.*)

How to Check Repair-Shop Prices for Rewinding *Induction Motors*



WHAT IS a fair price for rewinding an induction motor? You have probably asked yourself this question frequently of late, whether you repair motors or have them repaired by others, owing to the changes in costs of materials and labor needed for a repair job. If you are repairing motors you need to know how to figure your prices to include a fair profit. If you send your motors out to be repaired, you should know how to estimate the cost of the job and check the bill when the motor is returned. As a guide in checking rewinding charges the accompanying list of prices is presented. This list shows prices for rewinding two-phase and three-phase induction motors of 110 volts to 2,200 volts at 50 to 60 cycles in two sections of the country where a wide range of motor repair work is handled. You must remember in using the list that it applies only to rewinding stators of standard construction. Any special feature will increase the cost. To check the cost of a special job some experience in rewinding and repair procedure is essential.

The Detroit list is compiled from figures from most of the shops in that city. The prices shown cover rewinding the stator, and taping all coil ends. In some cases a guarantee of three months is given, but usually no guarantee is given. For a one-year guarantee 25 per cent is added to the list price and in such a case a more thorough job is done on the motor, better insulating materials are used, better workmanship is put in the job, and dipping and baking is done with more care. The Los Angeles prices include a year's guarantee, but cover taping the coil ends only when the ends were taped on the motor as received.

In figuring the cost of a job, the first step is to get the full nameplate data of the motor. Then if the motor is of a type with which the repair-shop men are not familiar, a number of other details of information should be obtained. Among these are the number of slots, the number of commutator bars, the approximate diameter of the armature or stator, the length of the iron, the type of winding (as two-layer, diamond, basket, etc.), whether the slots are open or closed, tightness of the winding in the slot and at the ends, the type of coils, and the number of wires in hand when winding the coils.

It is the practice of most shops to send out an experienced winder to inspect the condition of a motor which must be repaired. He takes all the data which has just been mentioned and makes notes of any special features of the motor. His inspection covers bearings, brushes, fields, and the like. If a price is desired at once, this man calls up the office of the shop and gives all the information which he has to the estimator. After the estimator determines the cost, the repair price is given over the telephone and this is later confirmed by letter.

THE PRICES published with this article have been compiled from records of rewinding costs in two sections of the country where rewinding jobs include a wide range of motors used in a variety of large industrial works. They do not include special cases, so that in using these prices as checks against your costs due allowance must be made for repairs to other than standard designs of motors.

Things That Run Up the Price of Repairing a Motor

There are a great many things which can make the cost run higher than you might expect. If a motor is oily and greasy, or if the winding has been impregnated, the time required for stripping is greater than otherwise. If the bearings have been allowed to wear and the rotor

Averages of Prices Charged by Repair Shops for Rewinding A. C. Stators

Hp.	Speed, R.P.M.	Charge for Rewinding 110, 220 and 440-Volt Motors (Dollars)	
		Detroit	Los Angeles
¼	1,800	.....	22
½	3,600	35	.....
½	1,800	30	26
½	1,200	33	31
½	900	42	.....
¾	3,600	37	.....
¾	1,800	33	31
¾	1,200	40	35
¾	900	43	.....
1	3,600	40	.....
1	1,800	33	35
1	1,200	40	39
1	900	47	58
1	720	50	.....
1	600	55	.....
1½	3,600	45	.....
1½	1,800	38	39
1½	1,200	43	43
1½	900	50	.....
1½	720	60	.....
1½	600	65	.....
2	3,600	50	.....
2	1,800	40	47
2	1,200	45	52
2	900	56	61
2	720	75	90
2	600	81	.....
3	3,600	54	.....
3	1,800	48	52
3	1,200	56	62
3	900	65	85
3	720	80	112
3	600	93	.....
5	3,600	60	.....
5	1,800	55	62
5	1,200	65	76
5	900	77	110
5	720	95	.....
5	600	110	.....
7½	3,600	72	.....
7½	1,800	68	77
7½	1,200	72	102
7½	900	90	118
7½	720	105	135
7½	600	115	151
7½	514	.....	230
10	3,600	95	.....
10	1,800	78	89
10	1,200	85	118
10	900	95	123
10	720	115	142
10	600	125	.....
.....	.....	.....	255

Hp.	Speed, R.P.M.	Charge for Rewinding (Dollars)		
		110, 220 and 440-Volt Motors		2,200-Volt Motors
		Detroit	Los Angeles	Los Angeles
15	3,600	120	.....	.....
15	1,800	95	110	177
15	1,200	105	118	186
15	900	115	138	197
15	720	140	196	.....
15	600	150	205	.....
15	514	.....	283	.....
15	360	.....	389	.....
20	3,600	130	.....	.....
20	1,800	115	116	184
20	1,200	120	132	200
20	900	130	178	220
20	720	154	224	.....
20	600	188	231	.....
20	514	.....	310	.....
20	450	.....	336	.....
25	3,600	155	.....	.....
25	1,800	123	125	199
25	1,200	135	167	204
25	900	145	190	223
25	720	180	254	285
25	600	210	267	.....
30	3,600	155	.....	.....
30	1,800	140	143	200
30	1,200	150	187	223
30	900	162	219	251
30	720	200	257	307
30	600	264	297	334
35	3,600	175	.....	.....
35	1,800	135	156	200
35	1,200	150	194	230
35	900	180	232	265
35	720	240	271	316
35	600	275	.....	.....
40	3,600	184	214	.....
40	1,800	165	170	200
40	1,200	184	203	235
40	900	203	247	278
40	720	270	287	325
40	600	308	331	360
50	3,600	195	248	.....
50	1,800	190	187	217
50	1,200	212	231	268
50	900	236	277	311
50	720	310	322	355
50	600	329	350	372
50	450	.....	441	.....
60	3,600	215	.....	.....
60	1,800	175	207	235
60	1,200	245	268	303
60	900	275	305	337
60	720	335	335	367
60	600	.....	365	390
60	450	.....	490	.....

Hp.	Speed, R.P.M.	Charge for Rewinding (Dollars)		
		110, 220 and 440-Volt Motors		2,200-Volt Motors
		Detroit	Los Angeles	Los Angeles
75	1,800	245	250	275
75	1,200	277	280	305
75	900	310	325	355
75	720	270	363	387
75	600	408	410	436
75	514	.....	.....	474
75	400	.....	.....	666
100	1,800	296	293	317
100	1,200	317	303	327
100	900	387	351	375
100	720	420	407	425
100	600	470	487	510
100	514	568	546	.....
100	450	595	577	597
100	400	.....	674	.....
100	360	.....	.....	782
125	1,800	.....	306	333
125	1,200	.....	342	365
125	900	.....	401	422
125	720	.....	437	459
125	600	.....	527	546
125	514	.....	600	.....
125	360	.....	.....	853
150	1,800	.....	357	379
150	1,200	405	422	446
150	900	425	448	481
150	720	465	468	493
150	600	570	560	581
150	514	656	652	675
150	450	756	.....	.....
150	400	.....	790	.....
200	1,800	.....	450	474
200	1,200	.....	515	545
200	900	520	549	566
200	720	580	552	600
200	600	656	626	654
200	514	740	.....	.....
200	450	800	.....	.....
225	1,200	520	.....	.....
225	900	572	.....	.....
225	720	610	.....	.....
225	600	684	.....	.....
225	514	760	.....	.....
250	900	610	.....	.....
250	720	684	.....	.....
250	600	765	.....	.....
250	514	800	.....	.....
250	450	845	.....	.....

These are prices charged in August 1921 for rewinding standard alternating-current stators of any make, of two or three phases, 50 or 60 cycles. The prices are quoted f.o.b. repair shop. Wound rotors cost the same as stators.

has rubbed on the stator, the cost of repairs will be increased. The teeth of the stator will be bent into the slot and must be straightened before rewinding.

On high-voltage machines the extra insulation requires a longer time to tape up the stubs, and so on. As an example, it might be well to mention the case of rewinding a 220-hp., 4,600-volt, six-pole, three-phase, 60-cycle synchronous motor having 72 slots and 72 insulated coils. It took 74½ hours to get the coils and wedges into this motor, to tie the coil ends to two rings, to put in and tie blocks between the coils at each end of the core in order to stiffen the winding, to tape all connections and to paint the motor.

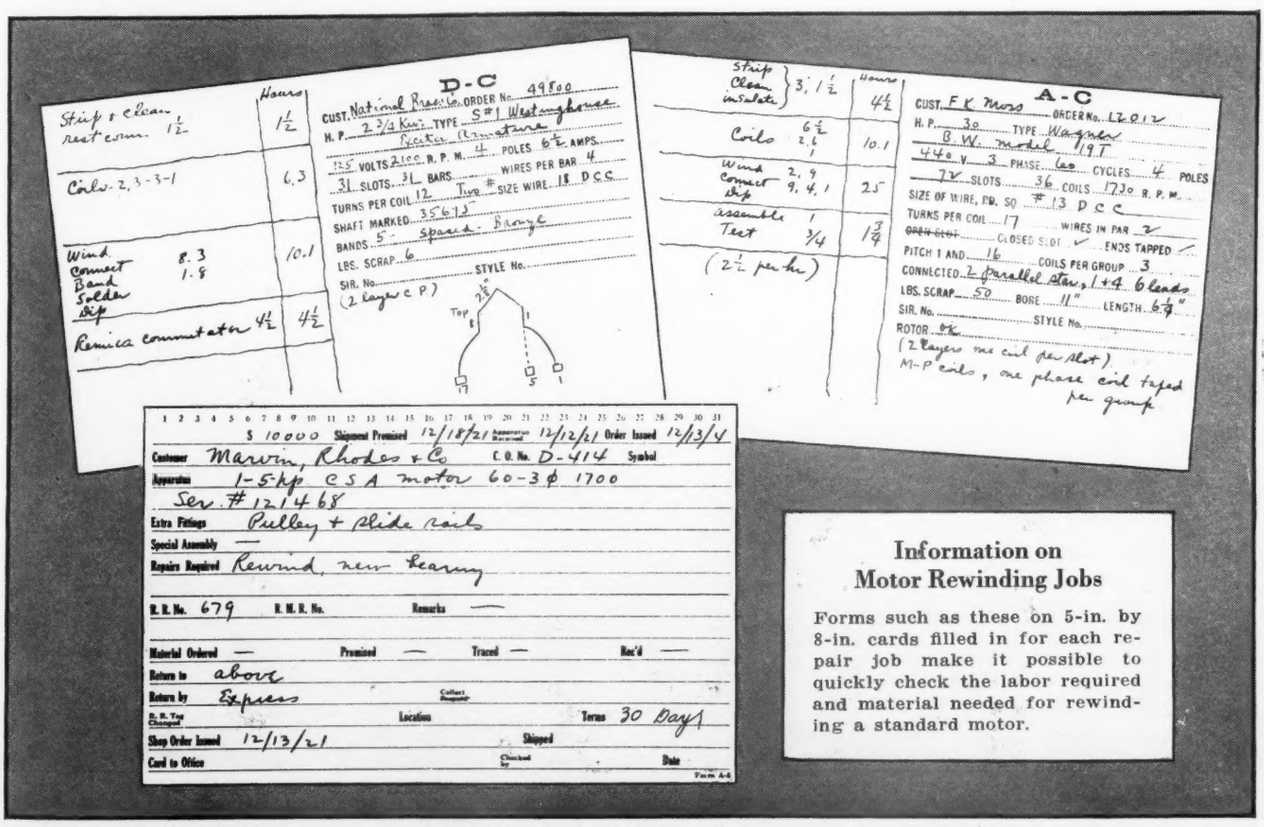
On the larger machines the wedges are an important item in the work. On the rotor of a 300-kw., 4,600-volt, three-phase, induction regulator, it required seven hours to remove the old wedges and fourteen hours to put in the new wedges, twenty-one hours in all.

Another case where the shop would have lost money if it had quoted the price without a very careful examination by an expert winder, was that of a 1/7-hp., 440-volt, three-phase, 60-cycle, 850 r.p.m. motor. The rewinding price for such a motor should be in the neighborhood of $25, but the actual time and material amounted to a good deal more than that. The principal reason was that there was very little room in the slot for the required number of wires and also very little end room. The motor had 36 slots and 36 coils of the diamond mesh type, wound in two layers. Each coil had 170 turns of one No. 26 single-cotton-and-enamel-covered wire and a pitch of 1 and 5. The ends of all coils were taped. The stator had a 4-in. bore and the iron was 1¾-in. long. It took 2½ hours to strip and clean the motor, 4 hours to make the coils, 27 hours to wind and connect the stator, and 1½ hours to test, dip and assemble. This made a total of 35 hours.

At another time a ¼-hp., two-pole, three-phase, 60-cycle motor was very difficult to wind on account of the fact that it had a small bore and a long core. There were 24 slots and 24 coils each having 26 turns of No. 19 double-cotton-covered wire with the ends taped, while the bore of the machine was 3⅛ inches and the length of the core 4¾ inches.

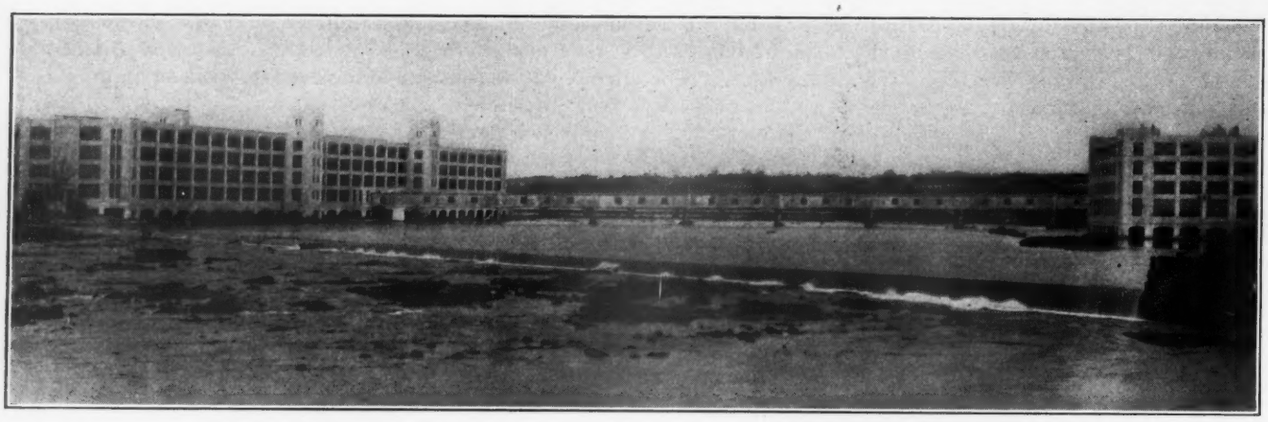
The best way for a repair shop to determine what the cost of a job will be is to look up the records of similar jobs. Some kind of a record should be kept by every repair shop and by those who have repair work done outside, for this purpose, giving the time required and the amount of material used on different jobs.

A very good way of keeping such a record is by means of cards such as those shown in the accompanying illustration. The face of the card shown is used for such information as the customer's name, and the like. On the back of the card a form is printed for detailed information on the machine to be repaired. Separate rubber stamps for repairs on alternating-current and direct-current motors are found convenient. Such a card serves as a report of progress, a shop record, a data sheet for use while repairing and a permanent reference file for estimating costs and other purposes. On the left-hand side of the back of the card the time required for each part of the job is recorded each day by the shop clerk. Where one job is going to be a duplicate of a former job, the time taken on the first job can be put down on the card before the work is started, as a check to prevent the time from running over what was required before. Data such as the pitch, coils and the throw of leads may be put down on the back of the card, as shown in the case of the alternating-current job.



Information on Motor Rewinding Jobs

Forms such as these on 5-in. by 8-in. cards filled in for each repair job make it possible to quickly check the labor required and material needed for rewinding a standard motor.



New weaving building of Riverside and Dan River Cotton Mills at left and raw stock dyehouse at right

In the Large Mill

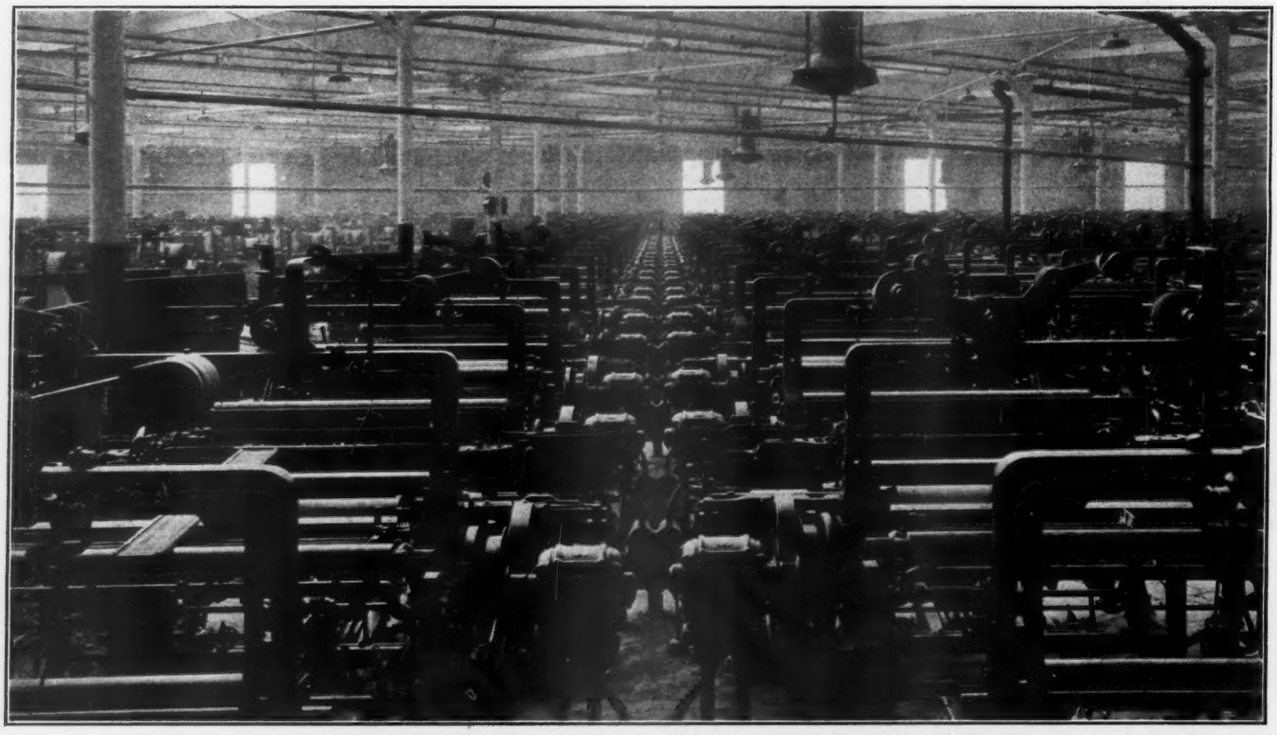
Flexibility of Electrical Service

Satisfies a Wide Range of Machine and Production Needs

TEXTILE mills of modern design make extensive use of electric service for power and lighting on account of the economy, convenience and flexibility which is possible. As an example, the new weaving building and raw-stock dyehouse of the Riverside & Dan River Cotton Mills at Danville, Va., contain many features of interest from this standpoint. In the weaving building recently completed there are no less than 5,040 motors, ½ hp. rating, each direct-connected to a loom. Besides these nearly one hundred other motors are in operation in these buildings. The lighting system is correspondingly large and the layout of the wiring installation is unusually comprehensive.

FROM CONDITIONING of air to the operation of 5,140 motors electric service facilities have been worked out in the Dan River mill as a fundamental part of the equipment in all departments. In many cases the building construction has provided new ideas in facilitating operation and maintenance from the standpoint of maximum production economies.

Lockwood, Greene & Company, Boston, Mass., were the designing



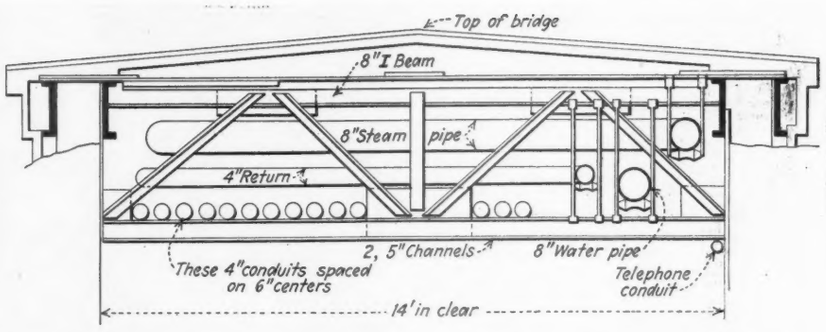
There are six hundred ½-hp. motors on this floor, each driving a loom.
When you look down this row of motors, you realize the important part played by the electrical department in mill operation.

engineers. The Aberthaw Construction Company, Boston, Mass., were the builders, while the wiring and other electrical work was installed by the Walker Electric & Plumbing Company, Atlanta, Ga.

Most of the electrical energy used by the Riverside Division mills is generated in the company's local steam and hydro-electric plants. These are situated on the north side of the Dan River and produce 60-cycle, three-phase energy at 600 volts. These generating plants total about 10,000 kw.

The older mills of the division as well as the new raw-stock dyehouse are adjacent. A study of the distribution problem for the new buildings indicated that it would be least expensive to distribute at 600 volts, three-phase for power service and avoid the use of power transformers. Loom motors designed for 550 volts were therefore selected and with few exceptions motors for other service run at this voltage. For lighting, 115-volt tungsten lamps are generally used, these being supplied by distributing circuits run from step-down transformers.

As the new weaving structure or Building No. 8, as it is known, is located on the south side of the river about 1,000 ft. distant from the older buildings, a new bridge was built to tie the various portions of the plant together and this bridge is conveniently utilized as a support for the feeders for lighting and power service which run from the steam generating-plant to the weaving building. Fourteen 600,000-circ. mil cables carry three-phase current over the bridge. Twelve cables are for power service and two are for lighting. The method of supporting these feeders, which are run in 3½-in. rigid conduit pipes carried on 5-in. channel-irons in the framing above the roadway and spaced 6-in. apart on centers, is illustrated above. This provides convenient access. Water, return and steam pipes are also carried across the river on these structural channels.



Details of upper framework of bridge

For the man who has a rubbing acquaintance with a drafting board this cross-section of the bridge cable and pipe runs is shown. A 6-in. conduit spacing was easily provided here from center to center.

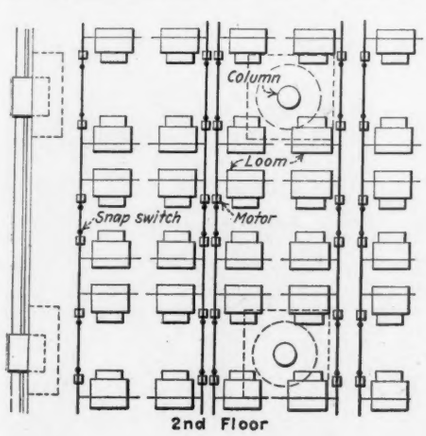
When the installation was first made some trouble developed with the 600,000 circ. mil cables from expansion in hot weather. The cable runs are about 1,000 ft. long with one joint in the center of each and there are easy bends near each end. There are about 8 inches of expansion in the conduit, part of which is taken up at the bends and the remainder is handled now by a slip-joint at the pull-boxes, formed by turning out the threads at one end of the pull-box and smoothing off the pipe. This has worked satisfactorily. There are about 16 inches of expansion in the cables. The engineers were of the opinion that part of this expansion would be taken up in the pull-boxes and the remainder at the ends where the cable was free to move in the pull-boxes. It was found, however, that the bends offered enough resistance to the cable movement to cause the pulling force of the expansion to be towards the center of the bridge. This forced the cable against the bottom of the pull-box with a sliding movement that wore the insulation off the cable at the joint, which is larger than the rest of the cable. Inspection showed no wear on the insulation of the cable itself.

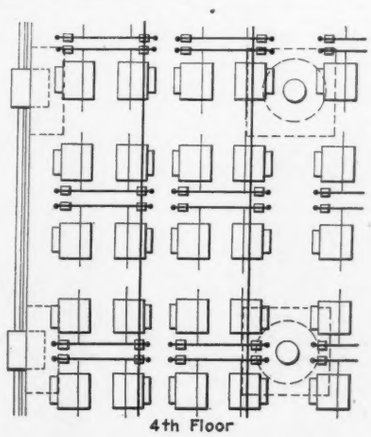
The pull-boxes have been lined with fiber, which is satisfactory as a temporary expedient, but as a permanent solution of the difficulty expansion loops have been put in the center of each cable. The method of procedure is to remove the cover, open the joints, pull the ends out of the box and insert a piece of cable long enough to give a loop outside the box and then build a cover over the loop, as illustrated.

The weaving building is four stories high with basement in addi-

The material used in this installation includes:

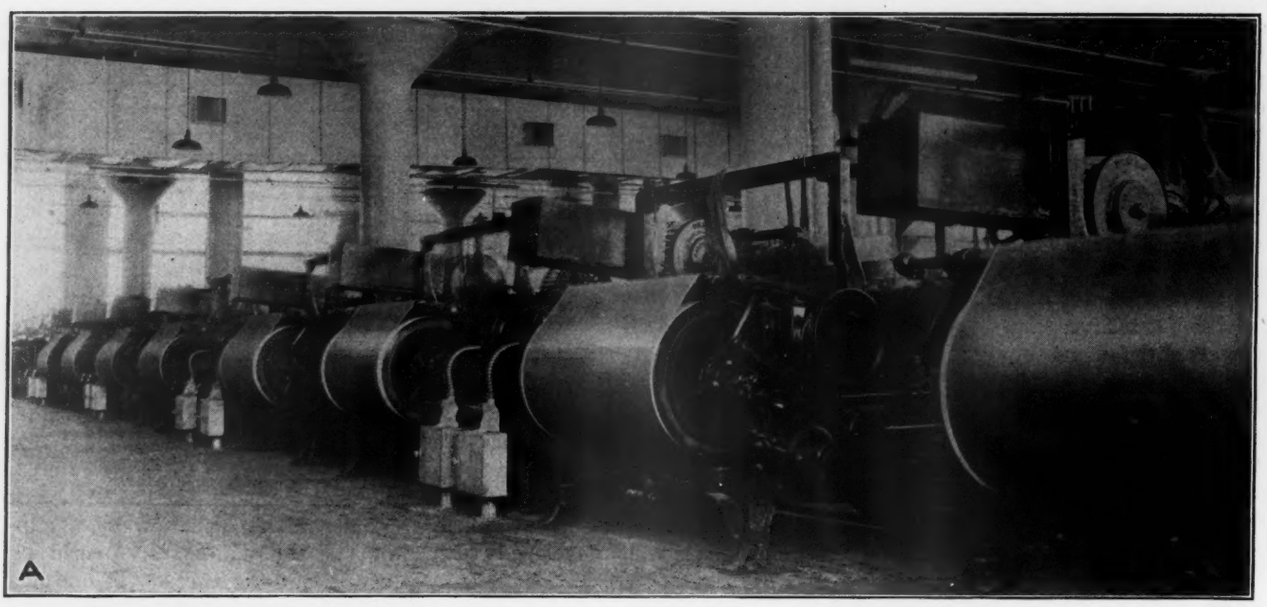
Over 16 miles of ¾-in. conduit.
Over 12 miles of 1 in. conduit.
Over 5 miles of 3½ in. conduit.
Over 36 miles of No. 12 R. C. wire.
Over 40 miles of No. 8 R. C. wire.
Over 16 miles of 600,000 circ. mil V. C. wire.
Over 7 tons of ¾-in. LB condulets.
Over 15,000 3-amp., 600-volt fuses.
Over 5,000 ½-hp. motors.
Over 4,000 lights with Ivanhoe reflectors.

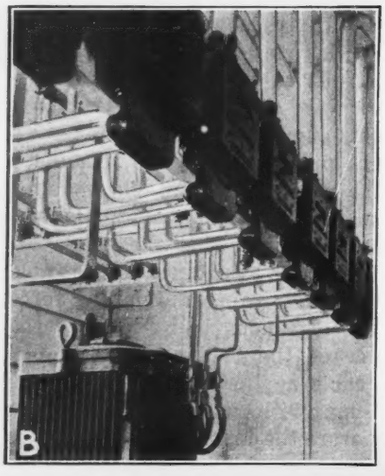




Arrangement of looms to eliminate cumulative vibration

Cumulative vibration is prevented by installing part of the looms with axes at right-angles to others. Sixteen looms per bay are provided and the dots and small squares represent snap switches and motors respectively. The solid feed lines are the conduit pipes run on the ceiling below with short risers to the motors. In either case, the motors and switches are accessible from aisles facilitating inspection and maintenance.





Some of the

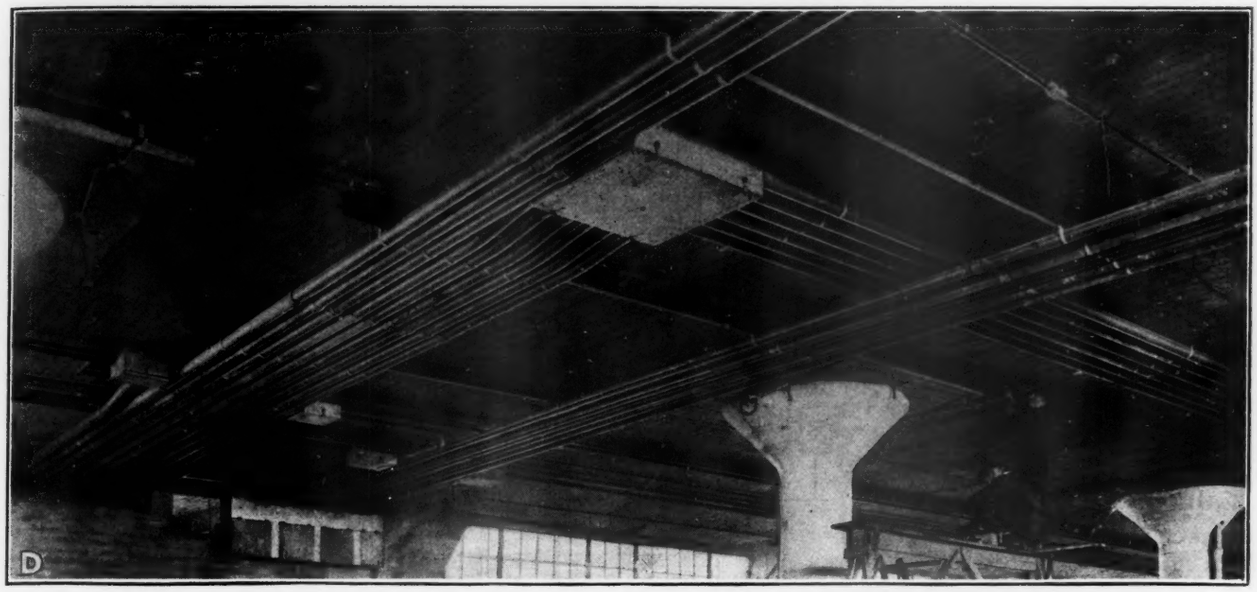
Electrical Features

of the Dan River Cotton Mills

A—Individual motors are controlled by push buttons located where they are easily accessible.

B—Cutouts for incoming lighting circuits are mounted at a convenient height above the lighting transformers. By this arrangement a minimum of material was needed between the 600-volt feeder entrances and the buses.

C—Good lighting is necessary to good work. Notice how uniform the illumination is in this room. This is the result of careful planning.

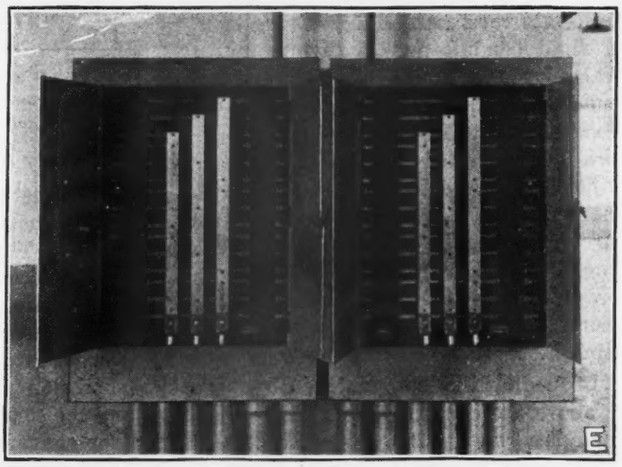


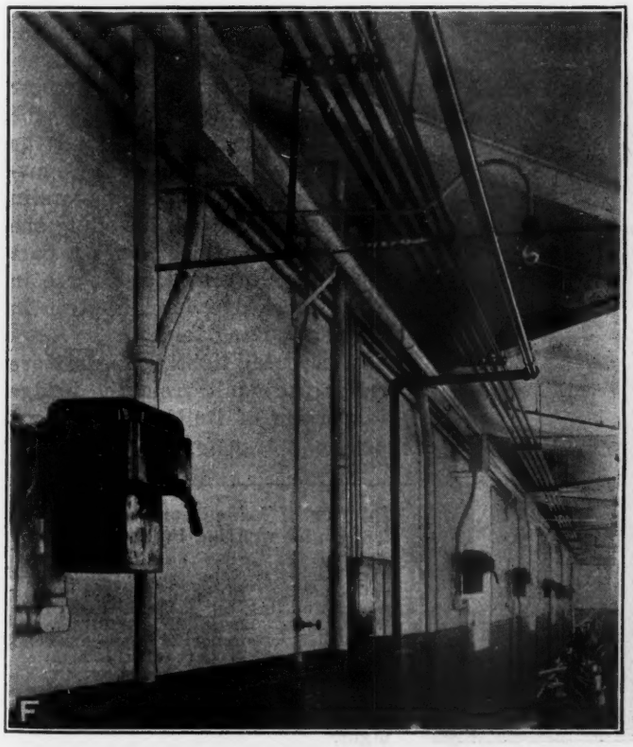
D—No surplus time is required to change wiring when every pipe and box is in such easy reach as those shown in this picture. Straight runs and right-angled turns at pull boxes allow quick work.

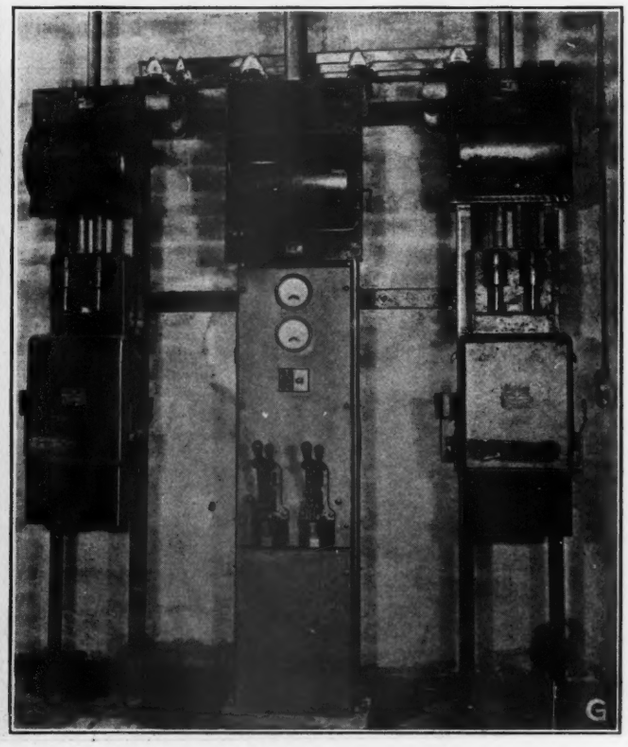
E—Having many circuits concentrated at one point allows quick replacement of fuses or cutting out of circuits when desired. The symmetry and good workmanship of this installation adds greatly to its appearance.

F—Switches mounted in orderly manner along the wall. The large pull boxes make easy work for the man pulling wire.

G—Two pumping units driven by 150-hp. motors are operated from this board. One of the switches in the middle panel throws the pump-motor bus on the mill service line, while the other switch throws it on an emergency feeder from the local light and power company.

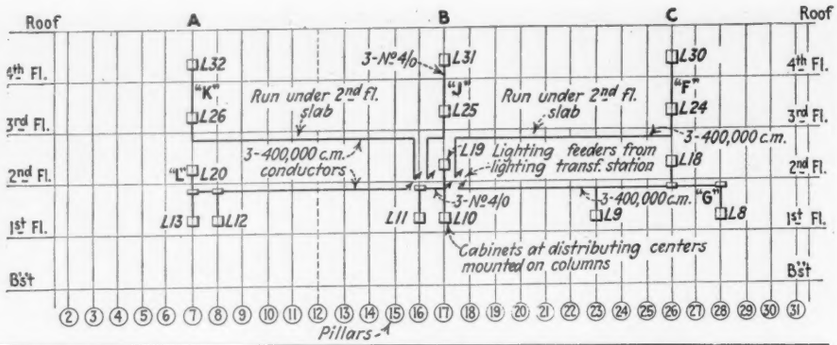






A simple way to show main feeders and cabinets at distributing centers

There are ways an d ways to make wiring diagrams on paper and on this Danville job a very handy one was used. Here is one without complications. The grid-iron drawing represents the elevation of the building with the number of each pillar in a circle at the bottom. The feeders and distributing-center cabinets are then indicated on the different floors. At a glance the operating man can tell at just what pillar every feeder shows itself, the size of the main runs and where they enter the mill.

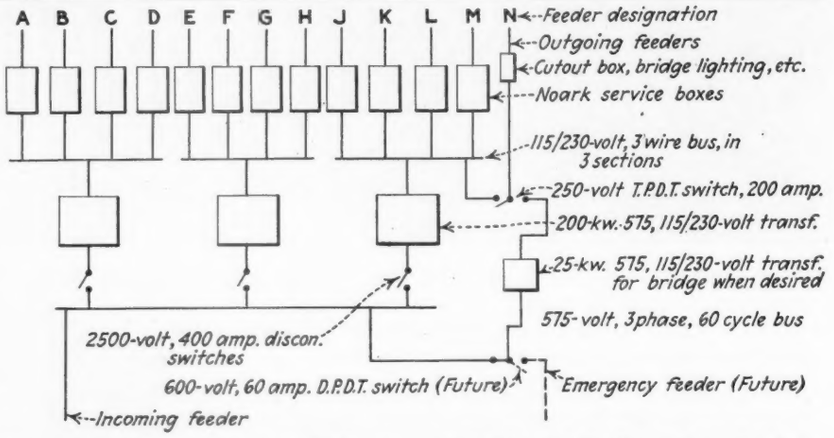


tion. It is 144 ft. wide and 840 ft. long, of reinforced concrete construction and having flat-slab floors and ceilings with mushroom columns. The power feeders are run into the weaving building from the bridge and branch in exposed form from cut-out boxes to various risers and cabinets feeding motors on the different floors. All of this wiring is in rigid conduit and its symmetry of layout and accessibility are unusual, as the accompanying illustrations indicate. In general, loom motors are mounted in pairs closely adjacent and are fed from below by short branch risers passing upward through the mill flooring into fittings provided with snap-switches; power is delivered to the motors by short runs of flexible armored conduit.

In feeding the loom motors directly above the chain dyehouse, type D condulets were tried, but came too high above the floor. As a result the box carrying the snap-switch was placed directly on type ET condulets with a short nipple and standard pedestal. This arrangement is shown in an accompanying drawing and has the advantage of minimum cost and was easy to wire.

All loom motors are located within easy inspection distance from the aisles and the conduit fittings are designed for convenience in pulling in leads, as shown in the photograph of typical loom driving. All motors are started and stopped by special attendants. This enables the motor switches to be mounted out of the way in the back alleys behind the looms, leaving the front of these machines clear. A list of the motors in the weaving building, including the chain dyehouse which forms a part of this structure, and also those in the raw stock dyehouse, is given in the accompanying table.

The incoming lighting feeders are carried in conduit from the bridge to a portion of Building No. 8 set apart as a transformer substation.

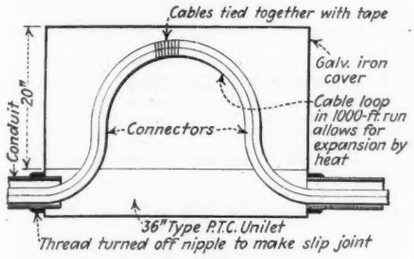

A B C D E F G H J K L M N ←Feeder designation
←Outgoing feeders
←Cutout box, bridge lighting, etc.
←Noark service boxes
115/230-volt, 3 wire bus, in 3 sections
250-volt T.P.D.T. switch, 200 amp.
200-kw. 575, 115/230-volt transf.
25-kw. 575, 115/230-volt transf. for bridge when desired
575-volt, 3phase, 60 cycle bus
2500-volt, 400 amp. discon. switches
600-volt, 60 amp. D.P.D.T. switch (Future)
Emergency feeder (Future)
←Incoming feeder

Flexible distribution of service for lighting from the transformer substation at weaving building

The layout provides for a regular and emergency feed to the primary buses, with single-phase distribution from the step-down transformers to lighting centers in the mill. Any feeder can readily be cut out of service for repairs or testing at this transformer substation which is located inside the building centrally to the load. It will be noted that the bridge can be lighted from either of two feeders as desired, thus saving losses in the larger transformers.

Interior of bridge connecting dyehouse and weaving buildings

This bridge across the Dan River is about 1,000 ft. long and serves both as a passageway and for carrying power and lighting cables, steam and water lines. The cable conduits rest on saddles, supported by channel irons that form part of the bridge framework above the roadway. Conduit and pipe lines are thus easily accessible. Ample provision has been made for lighting the bridge at night.


Cables tied together with tape
Galv. iron cover
Cable loop in 1000-ft run allows for expansion by heat
Conduit
20"
Connectors
36" Type P.T.C. Unilet
Thread turned off nipple to make slip joint

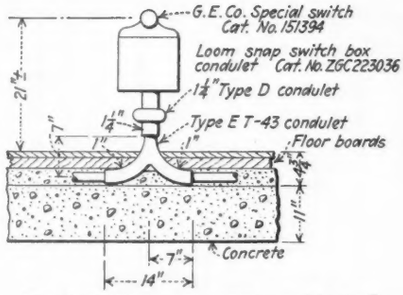
Expansion loop that takes care of sixteen inches of cable movement

When the 1,000-ft. conduit lines carrying 600,000 cir. mil cables felt the full effects of the Virginia sun and stretched out some 8 inches the need for taking care of expansion was evident. Trouble from insulation chafing off led to the provision of expansion loops in thepipes at the center of their run. It is expected that this will end the difficulty. Read the details in the article.

Here a bank of three 200-kva. single-phase transformers supplies energy over a three-wire system at 115-230 volts for general lighting and a 25-kva. transformer serves an installation of pilot lights by which watchmen and others can proceed about the mill conveniently when the main lighting circuits are open. Provision for cutting out any incoming lighting feeder is made in the substation and the local 115-230 volt feeders from the transformer house can likewise be segregated.

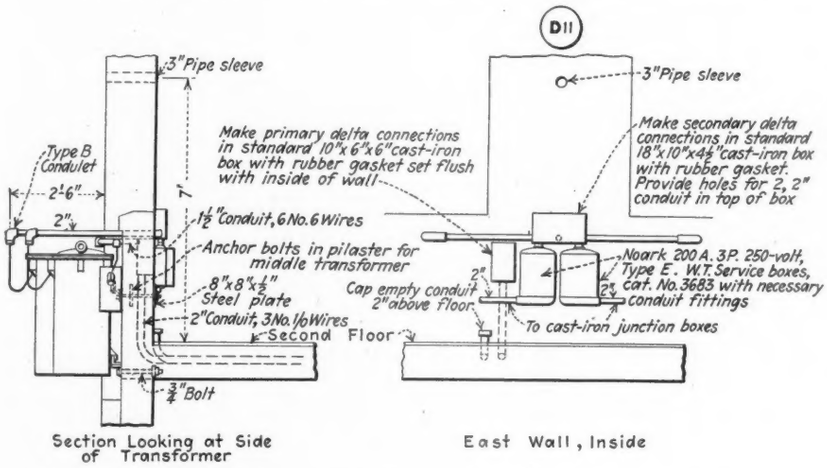
In general, the weaving building is illuminated by 200-watt Mazda C lamps mounted four per bay in R.L.M. reflectors, 11 ft. 6 in. above the floor and 14 ft. apart. The bays are 28 ft. square. Weaving is done on the three upper floors and an intensity of illumination of about 10 foot-candles is attained, this being used on account of the colored goods woven in the establishment. Gloss-white paint is used on the walls and ceilings.

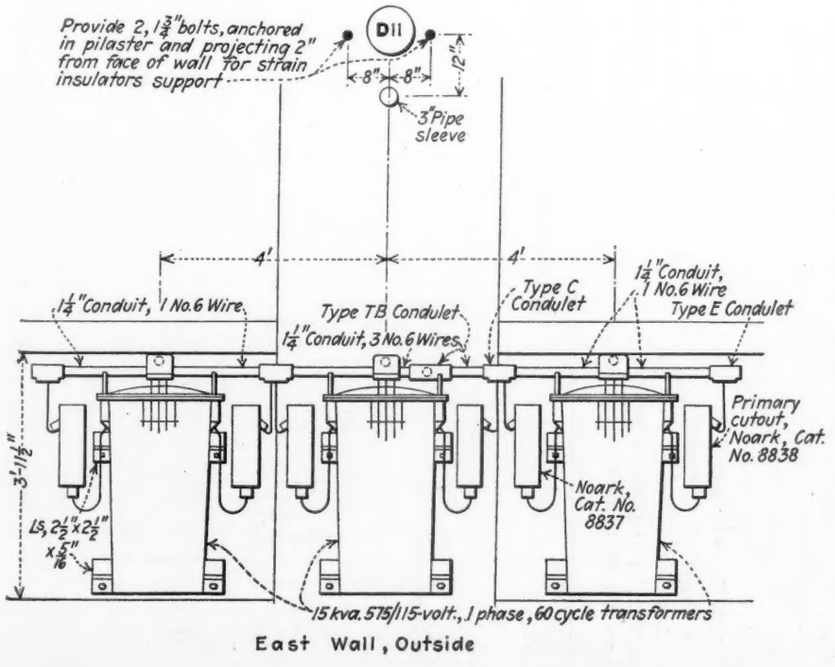
With the exception of main feeders and risers, which are in exposed rigid iron conduit, all wiring for lighting is run in concealed iron conduit. In general, the distribution for each floor is from two centralized, adjacent safety-type cabinets fed by risers leading from the transformer substation to these points, with three 200-watt lamps per local circuit controlled by a switch in the cabinet from which the local circuit is supplied. Outlets are arranged in longitudinal lines parallel to the outer walls so that the amount of interior lighting can be easily controlled in accordance with the external weather conditions. Thus, on a typical floor, a single row of the lamps farthest from the windows can, if desired, be lighted before those which are nearer; and even the lamps in the interior rows are subdivided in control to allow the overseers to get rid of any local "dark spots." The wiring for the lighting of the other sections of the building is modified somewhat to meet local machinery requirements, but in the chain dyehouse and raw-stock dyehouse ample provision for subdivision of lighting control is made. Enameled steel, vapor-proof reflectors are used in the latter department and immediately above the chain dyehouse in Building No. 8 the feeders for both power and lighting service are imbedded 4¾ in. under the concrete *(Continued on page 101.)*



Special fitting connecting cable and motor switch box

In one part of the weaving building there is a chain dyehouse and to avoid possible ill effects of the atmosphere on pipe conduit this conduit was embedded in the ceiling. To reach the motors on the floor above the special condulet fitting shown here was installed, making it easy to bring the feed to the motor switch box from the, concealed conduit below. This is an ingenious solution of a problem which was both electrical and mechanical.


D11
3" Pipe sleeve
Type B Conduulet
2'-6"
2"
7'
1½" Conduit, 6 No. 6 Wires
Anchor bolts in pilaster for middle transformer
8"x8"x½" Steel plate
2" Conduit, 3 No. 1/0 Wires
Second Floor
¾" Bolt
Make primary delta connections in standard 10"x6"x6" cast-iron box with rubber gasket set flush with inside of wall
Section Looking at Side of Transformer
3" Pipe sleeve
Make secondary delta connections in standard 18"x10"x4½" cast-iron box with rubber gasket. Provide holes for 2, 2" conduit in top of box
Noark 200 A. 3P. 250-volt, Type E. W.T. Service boxes, cat. No. 3683 with necessary conduit fittings
2"
2"
Cap empty conduit 2" above floor
To cast-iron junction boxes
East Wall, Inside



Some details of a good mounting for lighting transformers

This transformer mounting for lighting service is a ship-shape job when compared with installations where transformers are merely sentenced by the designing engineer to "be hanged by the neck until dead" from any nearby pole or eye-sore of a platform.

A Good Way to File
Motor-Drive Information

Compiled by E. S. LINCOLN
Industrial Engineer, Portland, Maine

THIS COMBINED motor inventory and test data sheet was originated by E. S. Lincoln, Industrial Engineer, Portland, Maine, for use in making power surveys and tests in industrial plants. It provides complete installation and service information, on the one hand, and make, type, rating, location and other record information, on the other. When this form is made on tracing cloth changes can be easily made and the previously dated blue prints taken therefrom constitute a continuous record of department drives from many standpoints.

THE LARGE record sheet below, showing data on motors in a shoe factory, is of value from two standpoints. In the first place, the record sheet itself is a very good form for recording the results of tests, the kind of drives used, different pulley and shaft information, and the like. This gives, in a practical manner, an inventory of the electrical equipment in a plant. In the second place, the figures on this particular sheet show the working and friction loads on motors driving various shoe-making machines and also the kinds of motors, starters, drives, and so forth, which are used.

The table contains information on twenty-four of the leading points of interest regarding motor applications in the plant. It provides a complete record for motor locations, ratings, fuse requirements, type of starter, manufacturer's number, owner's number, character of the machinery driven, the load on each motor when working, the friction load, the number of shafts driven from each motor, the number of bearings, and the number and type of belts. After such data is recorded a study of the sheet will show at once how closely the motor ratings correspond with their duties. Such a study will reveal when a motor is too large or too small for its service. Tests of this kind should be made every now and then, so that a comparison of successive sheets will show where the loads have changed and allow motors to be shifted if necessary.

The original sheet from which this table was made contained one column which is not shown here. This column was for the company's number of each motor. If desired, the first column may be used for this purpose, though in the table shown the first column is used for the test number of the motor.

Report of Motor Tests and Drive Equipment at Large Shoemaking Plant

(Two Factories Are Included)

Motor No.	Bldg. ‡	Floor ‡	Make §	Maker's No.	Type	Form	Location ‖	Rated Hp.	R.p.m.	Amp.	Pulley Dia., In.	Pulley Face, In.	Starter ¶	Amp. of Fuses	Equipment Operated	Shafts**	Bearings	Belts ††	Friction Load, Hp.	Working Load, Hp.	Hour of Test‡‡	Date, Nov.
1	M	1	West.	950876	CCL	Style 75460	F	15	1,120	15	8	7	C	30	Blower No. 2369	.....	..	1	None	21	10.00	7
2	M	1	Ft. W.	493538	M.A.	C	C	1	1,800	1.4	4	2½	S	6	Machine shop	3	11	6	0.47	1.33	10.45	7
3*	M	1	G.E.	464693	K.F.	C	C	5	1,800	5.2	4½	4½	S	10	Carpenter shop	3	6	4	1.3	1.4	11.00	7
4	3	B	G.E.	426095	I.	K	Pl	20	1,200	20	9	7	C	30	Blower	.....	..	1	None	13.3	3.30	7
5†	3	B	G.E.	483324	K.T.	C	C	7.5	1,800	7.4	5	4½	C	10	2 Drying out machines, 1 heel pricking machine	1	9	7	2	10.67	4.15	7
6	3	B	G.E.	430555	K.T.	K	C	7.5	1,800	7.4	5	4½	C	10	Elevator	2	4	3	1.6	2.67	8.15	8
7	3	B	Ft.W.	542471	M.A.	C	C	1.	1,800	1.4	2½	2½	S	6	6 Assemblers	1	5	7	0.4	0.8	9.15	8
8	3	1 P	G.E.	428210	K.	C	C	0.5	1,800	0.72	2½	2½	S	3	1 Button machine, 1 brushing machine, 1 sewing machine, 1 toe a tacher, 1 pounding machin	2	12	5	0.27	0.54	10.00	8
9	3	1 F	G.E.	521041	M.	C	C	10	1,200	10.5	8	4¼	C	25	18 Finishing machines	1 M. 15 C.	15	18 L. 15 S.	3.7	12	10.15	8
10	3	1 F	G.E.	432862	K.T.	C	C	3	1,800	3	3½	3½	S	10	8 Finishing machines	1	6	8	1.2	2.66	10.45	8
11	3	1	W.E.	526578	CL-4C	..	C	2	1,800	2.2	4½	2½	S	6	3 Finishing machines	4	8	5	0.66	1.98	11.15	8
12	3	2	G.E.	433822	K.T.	C	C	7.5	1,800	7.4	5	5	C	10	3 Pounding machines, 6 sole tacke s, 3 chip buffers, 7 McK. sewers, 3 cement machines	1 L.	19	26	4.6	9.5	1.15	8
13	3	2	Ft. W.	523704	M.	C	C	15	1,200	16	7	7	C	30	22 Lasting machines	1 L.	13	22	3.3	5.33	2.00	8
14	3	2	Ft. W.	529514	M	C	C	5	1,800	5.2	4	4	S	10	3 Pounding machines	1	4	3	0.6	4.0	3.00	8
15	3	2	G.E.	431288	K.T.	C	C	7.5	1,800	7.4	4½	4½	C	10	8 Trimmers, 1 wheeler, 1 heel scalloper, 8 setters, 4 small air pumps	1	12	18 4 R.	3.33	9.33	8.30	15
16	3	2	G.E.	495589	K.T.	C	C	10.	1,800	9.5	8	5	C	25	4 Leveling, 4 heeling, 2 emery wheels, 4 sluggers, 4 heel shavers.	1–120′ 1–15′	16	25	5.0	10.75	9.15	15
17	3	2	W.E.	641063	K.T.	O	C	5	1,800	5.2	4½	4½	S	10	4 Heel scouring, 2 brest scouring, 1 Louie heel dresser	1	6	8	2.66	7.0	9.45	15
18	3	2	G.E.	464720	K.T.	C	C	3	1,800	3.	4	4	S	10	3 Heel pressers	1	4	3	0.8	2.0	10.15	15
19	3	2	Ft. W.	481081	M.A.	C	C	2	1,800	2.2	4½	3½	S	6	6 Mixers	1–30′ 1–6′	6	6	0.25	0.27	10.45	15
20	3	4	G.E.	466395	K.T.	C	T	5	1,800	5.2	4	5	S	10	12 Skiving machines, 18 sewing machines, 5 marking machines	1	11	1 Z	1.06	1.5	11.15	15
21	3	4	G.E.	469032	K.T.	C	T	2	1,800	2.2	4	3	S	6	6 Perforating machines, 2 lining stampers	1	12	1	0.54	0.76	1.00	15
22	3	4	W.E.	644650	K.T.	C	C	5	1,800	5	4½	5½	S	10	5 Clicking machines, 2 stones, 1 emery wheel	1	4	9	2.26	3.4	2.30	15
23	3	4	G.E.	430810	K.T.	C	C	7.5	1,800	7.4	4½	5	C	10	3 Clicking machines, 1 drying out machine, 1 emery wheel	1	7	6	1.33	5.0	2.00	15
24	3	4	G.E.	430811	K.T.	C	C	7.5	1,800	7.4	5	5	C	10	3 Am. welt., 2 founders, 1 blower, 1 tip buffer, 3 lasting ma-							

22	3	4	W.E.	644650	K.T.	C	C	5	1,800	5	4½	5½	S	10	5 Clicking machines, 2 stones, 1 emery wheel	1	4	9	2.26	3.4	2.30	15
23	3	4	G.E.	430810	K.T.	C	C	7.5	1,800	7.4	4½	5	C	10	3 Clicking machines, 1 drying out machine, 1 emery wheel	1	7	6	1.33	5.0	2.00	15
24	4	1	G.E.	430809	K.T.	C	C	7.5	1,800	7.4	5	5	C	10	3 Am. welt., 2 founders, 1 blower, 1 tip buffer, 3 lasting machines	2	10	12	4.98	5.05	2.30	15
25	4	1	Otis	25636Y	....	Style 7½AC	F	10	900	14.	..	..	Spe.	25	Elevator	....	..	G	10.5	13.8	3.15	15
26	4	1	Ft. W.	540118	M.A.	C	C	7.5	1,800	7.4	5	4½	C	10	5 Feather edgers, 1 lasting machine, 2 channel openers, 1 cementer, 2 assemblers, 1 toe gulger, 2 pullover machines, 2 burnishers, 2 sole moulders, 1 emery wheel, 1 skiving machine, 3 channelers, 1 sanding machine, 1 tap shaver, 3 ruffrounders	4	22	29	3.6	4.3	4.00	15
27	4	1	Ft. W.	537040	M.A.	C	C	5	1,800	5	4½	4½	S	10	2 Feather edgers, 1 innersole channeler, 1 shank reducing machine, 2 cementing machines, 2 stitching machines, 2 wetting machines, 2 universal channelers, 1 forming machine, 1 sizing machine, 1 reinforcing machine, 1 lip turner, 1 bare stitch machine, 1 turn channel machine, 1 Goodyear flexible, 1 tap trimmer, 1 sole machine, 1 rolling machine	3	14	20	2.95	3.4	5.00	15
28	4	2	Ft. W.	540748	M.A.	C	C	1	1,800	1.4	3½	2½	S	6	4 Bottom finishers	1	4	5	0.95	1.06	8.15	16
29	4	2	Ft. W.	540141	M.A.	C	C	7.5	1,800	7.4	5½	4½	C	10	2 Blacking machines, 6 buffers	1	5	9	2.8	3.0	8.45	16
30	4	2	Ft. W.	541482	M.A.	C	C	3	1,800	3	4	3½	S	10	4 Heel burnishers, 1 stamping machine, 7 brushes, 1 wheeling machine, 1 Louie brester, 1 wooden heeler	1	9	16	1.85	3.1	9.15	16
31	4	2	Ft. W.	539326	M.A.	C	C	0.5	1,800	0.6	2½	2½	S	3	1 Brush, 1 button machine, 1 sewing machine	1 M. 2 C.	9	4 A.P. 4 3 R.	0.47	5.0	9.45	16
32	4	3	Ft. W.	540120	M.A.	C	C	7.5	1,800	7.4	5	4½	C	10	2 Heel scourers, 7 edge setting machines, 2 edge trimmers, 1 wheeler, 3 air pumps	1	11	15	3.0	3.5	10.15	16
33	4	3	G.E.	187344	K.T.	C	C	5	1,200	5.4	5	4½	S	10	1 Heel shaver, 2 heeling machines, 2 loose nailers, 1 leveler	1	5	9	3.0	3.3	10.45	16
34	4	3	Ft. W.	541021	M.A.	C	C	3	1,800	3.0	4	3½	S	0 10	1 Heel shaver, 1 heel brester, 2 emery wheels, 1 heel scourer	1	4	6	1.7	1.8	11.15	16
35	4	3	Ft. W.	542544	M.A.	C	C	5	1,800	5.2	4	4½	S	10	1 Emery wheel, 2 jointing machines, 5 edge trimmers	1	5	9	2.8	3.0	1.00	16
36	4	3	G.E.	434268	K.T.	C	C	7.5	1,800	7.4	5	5	C	10	3 Heel scourers, 2 heel shavers, 2 bresters, 2 loose nailers, 1 emery wheel, 3 heelers	1	8	18	3.3	3.7	1.30	16
37	4	3	Ft. W.	540144	M.A.	C	C	7.5	1,800	7.4	5	4½	C	10	1 Small grinder, 2 loose nailers, 4 Goodyear sewers, 1 heel seat trimmer, 3 burnishers, 3 beating out machines, 1 reducing machine	1	9	19	2.9	3.4	2.00	16
38	4	3	Ft. W.	529534	M.A.	C	C	5	1,800	5.2	4	4	S	10	3 Goodyear sole stitchers, 1 open channeler	1	5	4	2.55	2.66	2.30	16
39		3	Ft. W.	532197	M.A.	C	C	7.5	1,800	7.4	5	4½	C	10	3 Universal rounding and channeling machines, 3 Goodyear sole layers, 3 Goodyear beating and slashing machines, 2 Goodyear inseam trimming machines, 4 Goodyear welt and turning machines, 1 Goodyear sole tacking machine, 2 Goodyear inner sole tack pullers, 1 Goodyear welt groover, 1 Goodyear shank stitching machine, 2 Goodyear cement machines, 1 Goodyear pounding machine	1–100′ 1–80′	12	15 10	3.1	3.85	3.00	16
40	4	4	Ft. W.	541046	M.A.	C	C	3	1,800	3.0	4	3½	S	10	1 Tip scouring machine, 2 tack pullers, 1 emery wheel, 2 staple machines, 1 upper trimming machine	1	6	7	1.6	1.75	3.30	16
41	4	4	Ft. W.	541483	M.A.	C	C	3	1,800	3.0	4	3	S	10	3 Staple machines, 1 moistening pump, 2 lasting machines	1–20′ 1–10′	3 2	4 4	1.75	1.85	4.00	16
42	4	4	Ft. W.	493438	M.A.	C	C	1	1,800	1.4	3	2½	S	6	3 Pullover machines	1	3	3	0.75	1.06	4.30	16
43	4	4	G.E.	250152	I.	L	C	10	1,200	10	10	8	C	25	1 Tip buffing machine, 2 tack pulling machines, 5 pounding machines, 2 stitching machines, 2 lasting machines, 3 pulling machines, 1 sole layer, 1 stitching machine (not running), 1 tacking-on machine, 1 tack puller (not running)	1 M. 2 C.	13 6	16 4	5.7	7.0	5.00	16
44	4	4	Ft. W.	540201	M.A.	C	T	1	1,800	1.4	2½	2½	S	6	6 Button machines	1	7	6	0.8	0.9	8.00	17
45	4	4	G.E.	467770	K.T.	C	T	1	1,800	1.4	2½	2½	S	6	3 Button machines	1	7	3	0.8	0.9	8.30	17
46	4	4	Ft. W.	538484	M.A.	C	T	2	1,800	2.2	3½	2	S	6	2 Ensign lacing machines, 12 sewing machines	1	10	2 12 R.	1.2	1.33	9.00	17
47	4	4	Ft. W.	541319	M.A.	C	WP	3	1,800	3.0	3½	3	S	10	21 Sewing machines	1	15	21 R.	1.7	2.0	9.30	17
48	4	4	Ft. W.	542319	M.A.	C	WP	2	1,800	2.2	3½	2½	S	6	8 Sewing machines	1	8	8 R.	1.2	1.33	10.00	17
49	4	4	Ft. W.	484911	M.A.	C	WP	2	1,800	2.2	3½	2½	S	6	11 Sewing machines	1	11	11 R.	1.2	1.33	10.30	17
50	4	5	G.E.	437461	K.T.	C	T	5	1,800	5.2	4	4	S	10	21 Sewing machines	1	23	2 21 R.	2.5	2.66	11.00	17
51	4	5	Ft.W.	541037	M.A.	C	WP	3	1,800	3.0	4	3½	S	10	24 Sewing machines	1	25	24 R.	1.85	2.13	11.30	17
52	4	5	Ft.W.	543267	M.A.	C	WP	5	1,800	5.2	4	4½	S	10	29 Buttonhole machines	1	26	29	2.4	2.6	1.00	17
53	4	5	Ft.W.	541349	M.A.	C	WP	3	1,800	3.0	4	4	S	10	20 Sewing machines	1	20	20 R.	1.6	1.8	1.30	17
54	4	5	Ft. W.	481298	M.A.	C	WP	2	1,800	2.2	4	2½	S	6	5 Sewing machines	1	6	5 R.	1.06	1.13	2.00	17
55	4	5	Ft. W.	540916	M.A.	C	P	1	1,800	1.4	2½	2½	S	6	7 Eyeletting machines	1	5	8	0.93	1.06	2.30	17
56	4	5	Ft. W.	527495	M.A.	C	T	5	1,800	5.2	4	5	S	10	14 Sewing machines	1 M. 1 C.	27	14 R. 2	2.66	3.0	3.00	17
57	4	5	W.E.	532457	Cl-4C	....	WP	2	1,800	2.2	3½	2½	S	6	10 Sewing machines	1	11	10 R.	1.2	1.45	3.30	17
58	4	5	G.E.	600793	K.T.	C	WP	5	1,800	5.2	4	3½	S	10	26 Sewing machines	1	27	2 26 R.	2.66	3.1	4.00	17
59	4	5	Ft. W.	541257	M.A.	C	T	3	1,800	3.0	3½	2	S	10	19 Sewing machines	1	21	19 R.	2.25	2.66	4.30	17
60	4	5	Ft. W.	501938	M.A.	C	T	1	1,800	1.4	3	2½	S	6	3 Beaders, 2 sewing machines	1	6	3 2 R.	0.66	0.8	8.15	18
61	4	5	Ft. W.	542298	M.A.	C	WP	2	1,800	2.2	4	2½	S	6	8 Sewing machines	1	4	8 R.	1.33	1.45	8.45	18
62	4	5	Ft. W.	540751	M.A.	C	T	1	1,800	1.4	3	2½	S	6	21 Small machines	1	12	21	0.93	1.06	9.15	18
63	4	5	A.-C.	60027	....	....	WP	2	1,700	2.2	4	3½	S	6	7 Sewing machines	1	10	7 R.	1.33	1.45	9.45	18
64	4	5/R	G.E.	467756	K.T.	C	P	1	1,800	1.2	3	2½	S	6	1 Lathe, 2 emery wheels	4	10	8	0.93	1.06	10.15	18

* Load consists of saw only.
† Intermittent load during test.
‡ Initials stand for buildings and floors, as follows: M = machine shop; B = basement; P = packing room; F = finishing room; R = repair shop.
§ Makers' names are abbreviated as follows: West = Westinghouse; Ft. W. = Fort Wayne; G.E. = General Electric; W.E. = Western Electric; A.C. = Allis-Chalmers.
‖ Location abbreviations are as follows: F = floor; C = ceiling; Pl = platform; T = table; P = post; WP = wall post.
¶ Starter abbrevations as follows: C = compensator; S = switch; Spe.. = Special.
** Shaft abbreviations are as follows: M = main shaft; C = countershaft.
†† Belt abbreviations are: L = large; S = small; R = round; G = geared; Z = several small belts.
‡‡ Blackface type shows afternoon time

	Hp.
Average working load of factory No. 3	73
Average friction load of factory No. 3	34
Average working load of factory No. 4	112
Average friction load of factory No. 4	77
Total for factories Nos. 3 and 4	185
Total loss	111

IN THIS ARTICLE repair shop practice is outlined for handling split windings, both chorded and diametrical, split loop windings and layer windings. Reasons are given for the use of these windings and their advantages in some cases over the straight loop winding which was outlined in detail in the January issue.

A. C. ROE

explains

Split and Layer Windings

for Small Armatures

A CHORDED-SPLIT winding is distinguished by the fact that the last two coils are visible on each side of the shaft, and parallel to each other, as shown in Fig. 2. This picture shows a complete winding with the insulation under each coil, and such armature with only a few coils in place. In Fig. 1 are shown the different steps which are taken, while *H* in Fig. 1 shows a diagram of the completed winding. Diagram *H* in Fig. 1 shows the slot each coil is started and finished in for this motor, which has twelve slots and is wound with a pitch of 1 and 6. The first coil is started, as shown in *A* of Fig. 1, by passing the wire through slot 1 around the back of the armature through slot 6 and back to slot 1. After the required number of turns has been put on, the wire is cut off on the commutator side of the armature and a red sleeve is put on the finishing lead while a white sleeve is put on the starting lead. These leads, of course, are left long enough to reach the commutator easily. It will be noticed that the wire is cut and loops are not made as with the loop windings.

After the first coil is in place the armature is rotated 180 deg. before starting the second coil, as shown in *B* of Fig. 1. Then after slot 7 has been placed at the top of the armature, the second coil is started in this slot, as shown at *C*, Fig. 1, and this coil is wound through slots 7 and 12 in the same manner as the first coil. The finishing lead comes out of slot 12, after which the wire is cut off and a red sleeve is put on it, with a white sleeve on the starting lead.

Special care must be taken to start coil 3 in the correct slot. To find this slot start at the finishing lead of coil 2, moving toward the right, as shown in *D*, Fig. 1; skip two slots and start the third coil in the third slot, which is slot 3. In other words, counting the slot where the finishing lead of coil 2 comes out as the first slot, move toward the right. The start of coil 3 will be in the fourth slot. When putting on the first turn of this coil place a strip of treated-cloth insulation both at the back and at the front of the armature beneath the turn covering the other coils. This insulation is always necessary with 110-volt or 220-volt motors and should be used even with 30-volt motors where there is enough room. After starting the coil in this manner wind it as you did the other coils. The finishing leads will come out of slot 8. Then rotate the armature 180 deg. again and start coil 4 in slot 9, passing through slot 2, out of which the finishing lead will come. Put insulation under this coil as you did under coil 3, and do likewise under all other coils which are put on. The next coil is then started in the third slot to the right from the finishing lead of slot 4, as was done in the preceding case. This slot, as you will see, is slot 5. The coil passes through this slot and slot 10, out of which its finishing lead extends, as seen in *F* of Fig. 1. Then the arma-

INSTRUCTIONS that are easy to follow for winding by hand the various types of small armatures are not easy to find. It usually takes considerable experience to learn the various kinks that help to speed up the winding process. The ideas and information in this article have resulted from much experience in handling a wide range of winding problems. This is the second article on winding direct-current armatures by Mr. Roe who is shop superintendent of the Detroit service department of the Westinghouse Electric & Manufacturing Company.

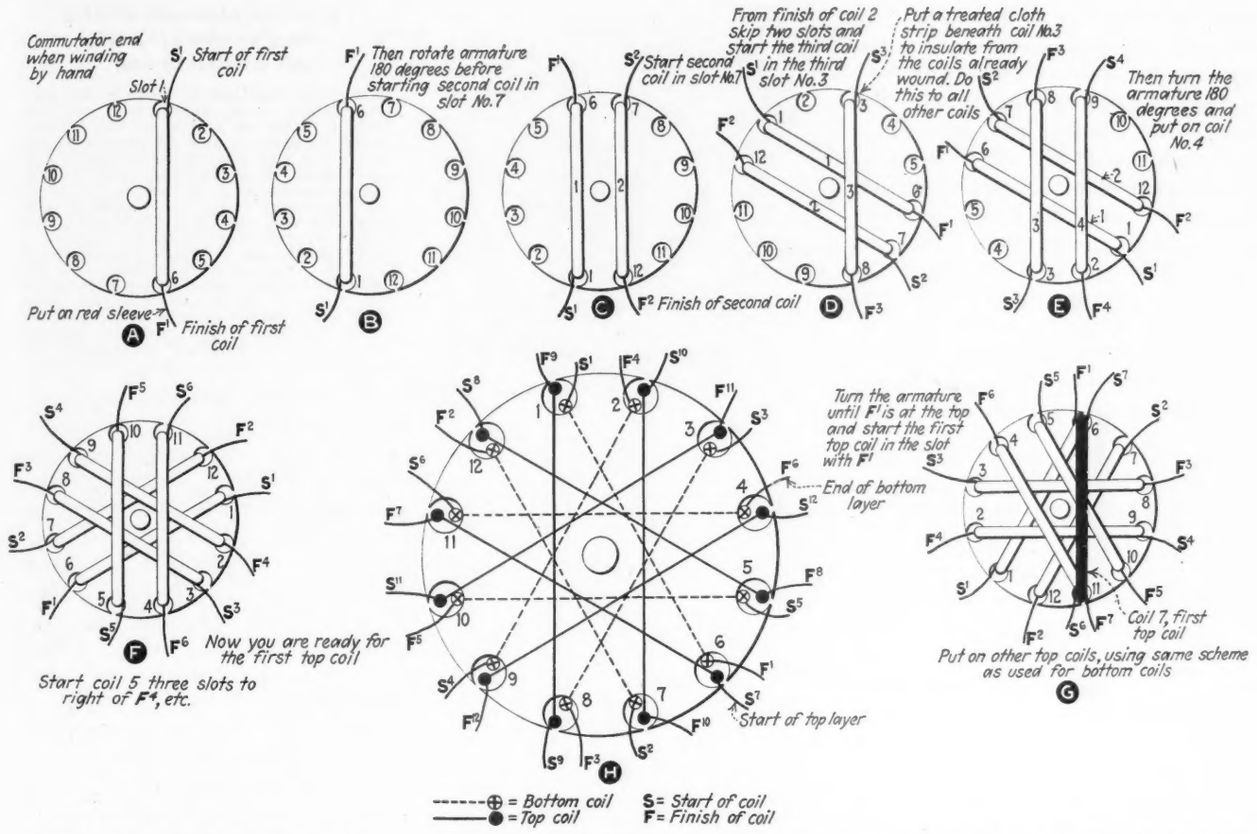

Commutator end when winding by hand
Start of first coil
Slot 1
Put on red sleeve
Finish of first coil
A
Then rotate armature 180 degrees before starting second coil in slot No. 7
B
Start second coil in slot No. 7
Finish of second coil
C
From finish of coil 2 skip two slots and start the third coil in the third slot No. 3
Put a treated cloth strip beneath coil No. 3 to insulate from the coils already wound. Do this to all other coils
D
Then turn the armature 180 degrees and put on coil No. 4
E
Now you are ready for the first top coil
Start coil 5 three slots to right of F4, etc.
F
End of bottom layer
Start of top layer
H
Turn the armature until F1 is at the top and start the first top coil in the slot with F1
Coil 7, first top coil
Put on other top coils, using same scheme as used for bottom coils
G
⊕ = Bottom coil
● = Top coil
S = Start of coil
F = Finish of coil

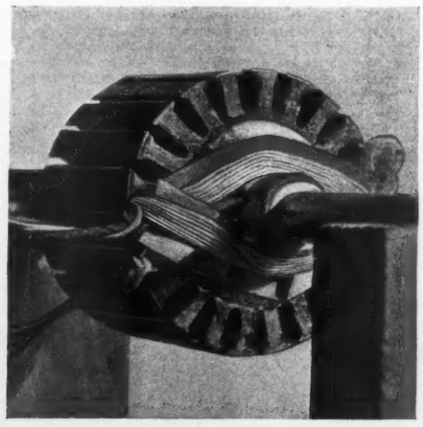
Fig. 1—A chorded-split winding is easy to put on if you follow these drawings.

If the number of slots can be divided by four, follow this scheme all the way through. If the number of slots is not divisible by four, Fig. 3 must be studied before starting on the coils in the top layer. In any case the number of coils must be even (divisible by two). At *H* is a diagram showing the completed winding. It also shows the slots where each coil was started and stopped. This armature has twelve slots and the pitch is 1 and 6. Fig. 2 shows photographs of this winding.

ture is rotated 180 deg. as was done before, and coil 6 is started in slot 11, as shown in *F* of Fig. 1. This completes the bottom layer of coils. It will be noticed that, taking the leads in rotation around the armature, the first one is a starting lead, the second one a finishing lead, the next a starting lead, and so on, in regular order.

In *G*, Fig. 1, is shown the first coil of the top layer in place. To find the slot in which this coil should be started begin with the finishing lead of the last coil in the bottom layer, skip one slot to the right, and in the second slot start the coil. This will mean that the first coil in the top layer will start in the same slot which holds the finishing lead of the bottom layer, or slot 6. You will notice that in this case, instead of skipping two slots to the right, only one slot was skipped. After the first coil of the top layer is in place the rest is easy, as the same scheme is followed that you used with the bottom coils. The diagram in *H* of Fig. 1 shows all the coils in place. It also shows just how the coils were put on, in what slots they were started, and finished.

The last two coils put on should be tied together by means of a stout cord in order to keep the wires from flying outward when the motor is



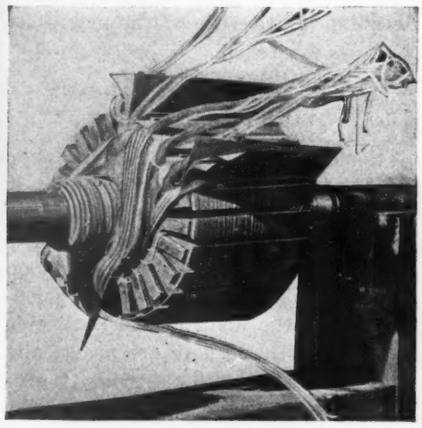


Fig. 2—This is the way a chorded-split winding appears.

At the left is the finished winding with the two last coils visible on each side of the shaft. In the center notice how a strip of insulation is put under each coil. See Figs. 1 and 3 for the steps to follow in putting on such a winding.

running. This cord is laid on the ends of the coils already wound before the last two coils are started.

The foregoing describes the method of winding by hand across the right-hand side of the shaft. The same method is used for winding with a machine except that the armature is turned away from the operator at the top instead of the wire being wound away from the operator. When using a machine, the coils may be wound on the left-hand side of the shaft next to the machine, if this is desirable.

Method of Putting on Chorded-Split Windings When the Number of Slots is Not Divisible by Four

If the number of slots is not divisible by four, the method of starting the top layer of a split winding is slightly different from that already described. Taking a fourteen-slot armature, as shown in Fig. 3, at *A*, after six coils have been put in place, there will be one empty slot on each side of the armature. To start the seventh coil, skip two slots to the right and start in slot No. 7. In other words, the 1 and 4 count is followed throughout the entire winding process. This is different from the method used when the total number of slots was divisible by four, as in such a case, instead of skipping two coils to the right, only one slot would have been skipped. The dotted lines in *B*, Fig. 3, show the next two coils in place. It will be noticed that the starting lead of each coil is put in a slot which already contains one coil, thus filling the slot. In *C*, Fig. 3, are shown the starting and finishing leads of all coils in place. These coils are put on in the same order as the coils in the bottom layer.

The method of connecting this winding to the commutator will be explained later.

Advantages of the Chorded-Split Type of Winding

Some of the good points in favor of this type of winding are that it distributes the winding across the ends more evenly, which gives a better balance than the straight loop winding. The coils are wound parallel across the end, one on each side of the shaft, and both are practically the same length. This tends to give a better mechanical balance. The resistance of the coils is more uniform as there are only six different sizes of coil for the armature which was described, while the loop winding would have twelve coils for the same number of slots and bars. The chorded-split winding takes up less end room than a straight loop winding, especially with large sizes of wire and numerous turns. When there is more than one bar to each slot, this type of winding will save time as the coils can all be wound at once by using as many wires in hand as there are coils per cell.

The chorded-split winding, however, has its disadvantages, among which are the twist of the armature back and forth when starting new coils, the constant testing to insure against mistakes and having to cut the wire at the end of each coil. This winding is also a little harder to connect to the commutator, as will be explained later.

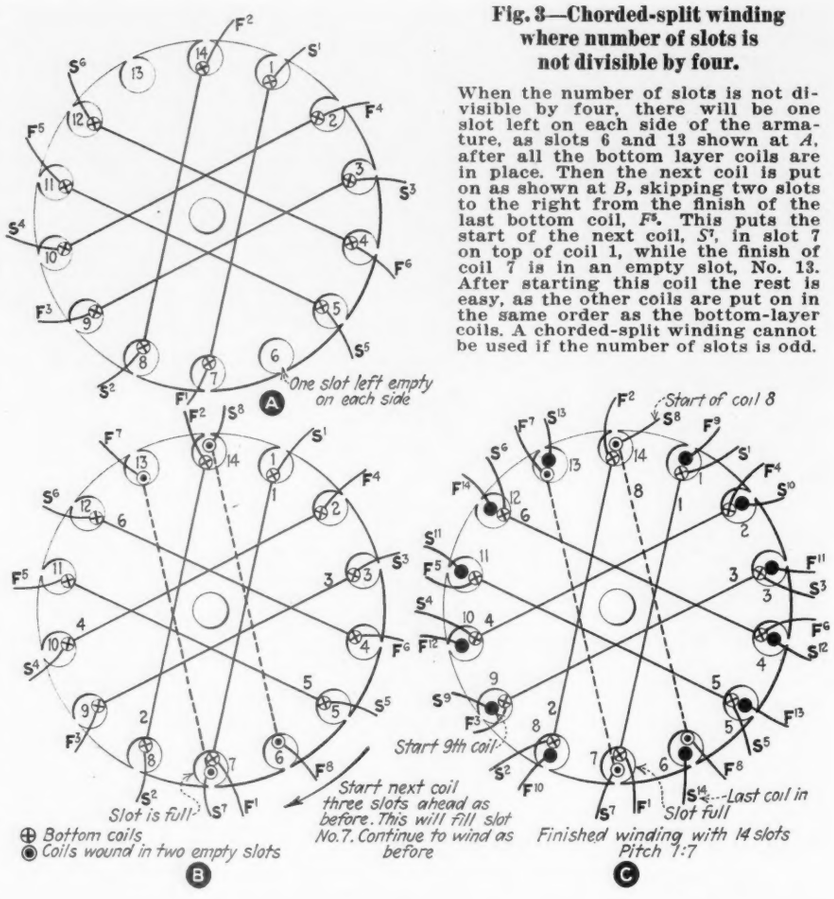

One slot left empty on each side
A
Start of coil 8
Start 9th coil
Slot is full
Start next coil three slots ahead as before. This will fill slot No.7. Continue to wind as before
Last coil in Slot full
Bottom coils
Coils wound in two empty slots
B
Finished winding with 14 slots Pitch 1:7
C

Fig. 3—Chorded-split winding where number of slots is not divisible by four.

When the number of slots is not divisible by four, there will be one slot left on each side of the armature, as slots 6 and 13 shown at *A*, after all the bottom layer coils are in place. Then the next coil is put on as shown at *B*, skipping two slots to the right from the finish of the last bottom coil, F^5. This puts the start of the next coil, S^7, in slot 7 on top of coil 1, while the finish of coil 7 is in an empty slot, No. 13. After starting this coil the rest is easy, as the other coils are put on in the same order as the bottom-layer coils. A chorded-split winding cannot be used if the number of slots is odd.

Fig. 4—A chorded split loop winding.

A pair of coils is visible when the armature is wound. This pair forms a V which incloses the shaft. If you are winding this kind of armature, follow Fig. 5 and the instructions in the article for details. The armature shown in the photograph has nineteen slots and is wound with a pitch of 1 and 8, leaving two slots (at the right) between the sides of the V. In Fig. 5 only one slot is included between the ends of the V.

Winding a Split-Loop Armature

The split-loop winding as shown in Fig. 4 might be called a combination of the two windings already explained, the split winding and the loop winding. The winding is divided on each side of the shaft and the wire at each end of the coil is formed into loops which are, however, cut before connecting to the

commutator. In this winding the two coils on each side of the shaft are not parallel to each other, as in the split winding, but form a V. Another distinctive feature is that after the first coil is wound in place each slot is filled as the winder proceeds.

Before starting the winding, slip on a number of sleeves of the proper size. For the twelve-slot armature shown in Fig. 5 twelve sleeves can be slipped on, alternating red and white. This will leave a white sleeve for each starting lead and a red sleeve for each finishing lead. After six coils are in place the wire is cut in order that twelve more sleeves may be put on which will be enough to finish the winding. As shown at *A* in Fig. 5, the motor taken for a sample was a twelve-slot machine and the coils had a pitch of 1 and 6. The first coil was started through slot 1 and across the rear end of the armature on the right-hand side of the shaft to slot 6. After the required number of turns is put on, the coil is finished in slot 6, leaving a red sleeve on the loop, as shown in Fig. 5. A white sleeve is left on the other side of the loop for the starting lead of the next coil. Before this is started the armature is rotated until the finishing lead of the first coil is at the top as shown at *B*, and then the second coil is started in the same slot on top of the first coil. Before starting each coil put a strip of treated-cloth insulation underneath to protect it from the other coils. After each coil is finished, continue in this manner, as shown at *C* in Fig. 5, until the entire armature is wound. As the winding progresses around the armature each slot will fill up, and on completion each slot will contain a starting and finishing lead, as shown in *D*, Fig. 5. The table under Fig. 5 shows in which slots the different coils start and finish.

This type of winding is used mostly on automobile-generator armatures, where the voltage is low, and hence insulation on the ends may be omitted if there is no room for it. However, for 110-volt or 220-volt armatures, a strip of insulation should always be placed under each coil at front and rear as explained.

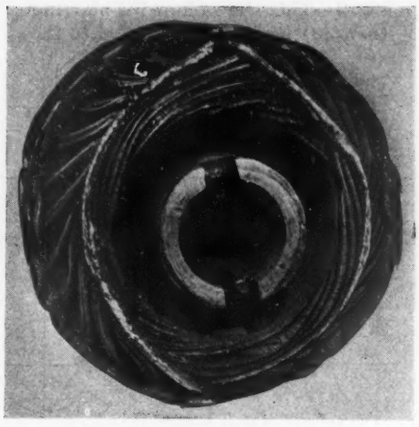


Fig. 6—This is a diametrically-split winding.

One coil is wound on both sides of the shaft in slots directly opposite each other. The chalk mark shows the last coil put on. In Fig. 8 you may see the steps followed in putting the coils in place.

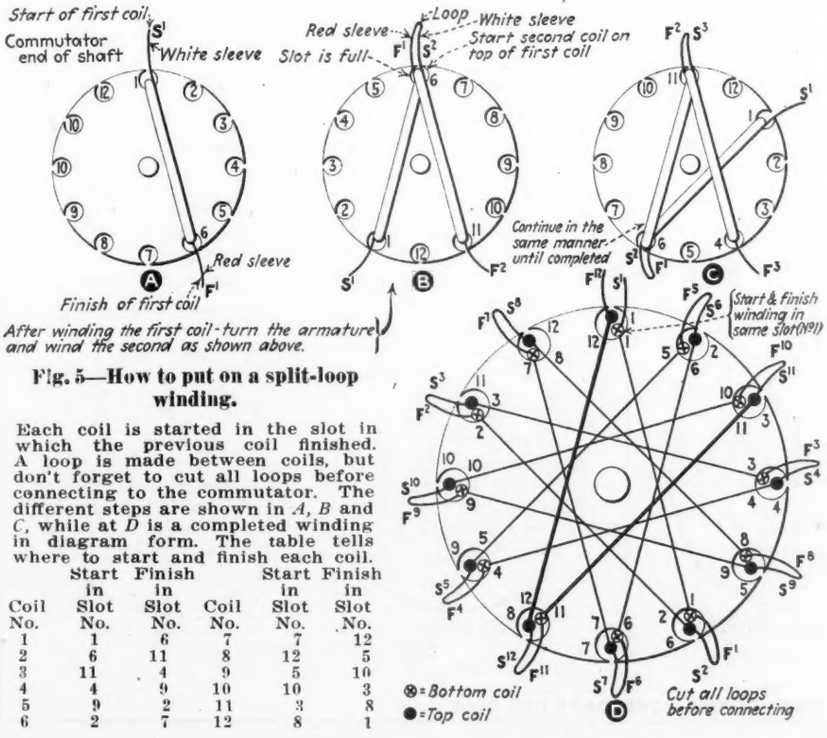

Start of first coil
Commutator end of shaft
White sleeve
Red sleeve
Slot is full
Loop
White sleeve
Start second coil on top of first coil
Red sleeve
Finish of first coil
Continue in the same manner until completed
Start & Finish winding in same slot(No1)
After winding the first coil-turn the armature and wind the second as shown above.
⊗=Bottom coil
●=Top coil
Cut all loops before connecting

Fig. 5—How to put on a split-loop winding.

Each coil is started in the slot in which the previous coil finished. A loop is made between coils, but don't forget to cut all loops before connecting to the commutator. The different steps are shown in *A*, *B* and *C*, while at *D* is a completed winding in diagram form. The table tells where to start and finish each coil.

Coil No.	Start in Slot No.	Finish in Slot No.	Coil No.	Start in Slot No.	Finish in Slot No.
1	1	6	7	7	12
2	6	11	8	12	5
3	11	4	9	5	10
4	4	9	10	10	3
5	9	2	11	3	8
6	2	7	12	8	1

Advantages and Disadvantages of the Split-Loop Winding

This winding has the same advantages and disadvantages as the split winding and the loop winding, but where the number of slots is great and the size of wire or the number of turns is large, while the space between the bottom of the slot and the shaft is small, the split-loop winding will occupy less space than either the split winding or the loop winding. This type of winding and the straight loop winding are independent of the number of slots, while the split winding can be used only when the number of slots is divisible by two. The winding shown in Fig. 4 is a split-loop winding, the armature having seventeen slots and the coils being pitched 1 and 8, leaving two slots between the open end of the V, while in Fig. 5 only one slot is left between.

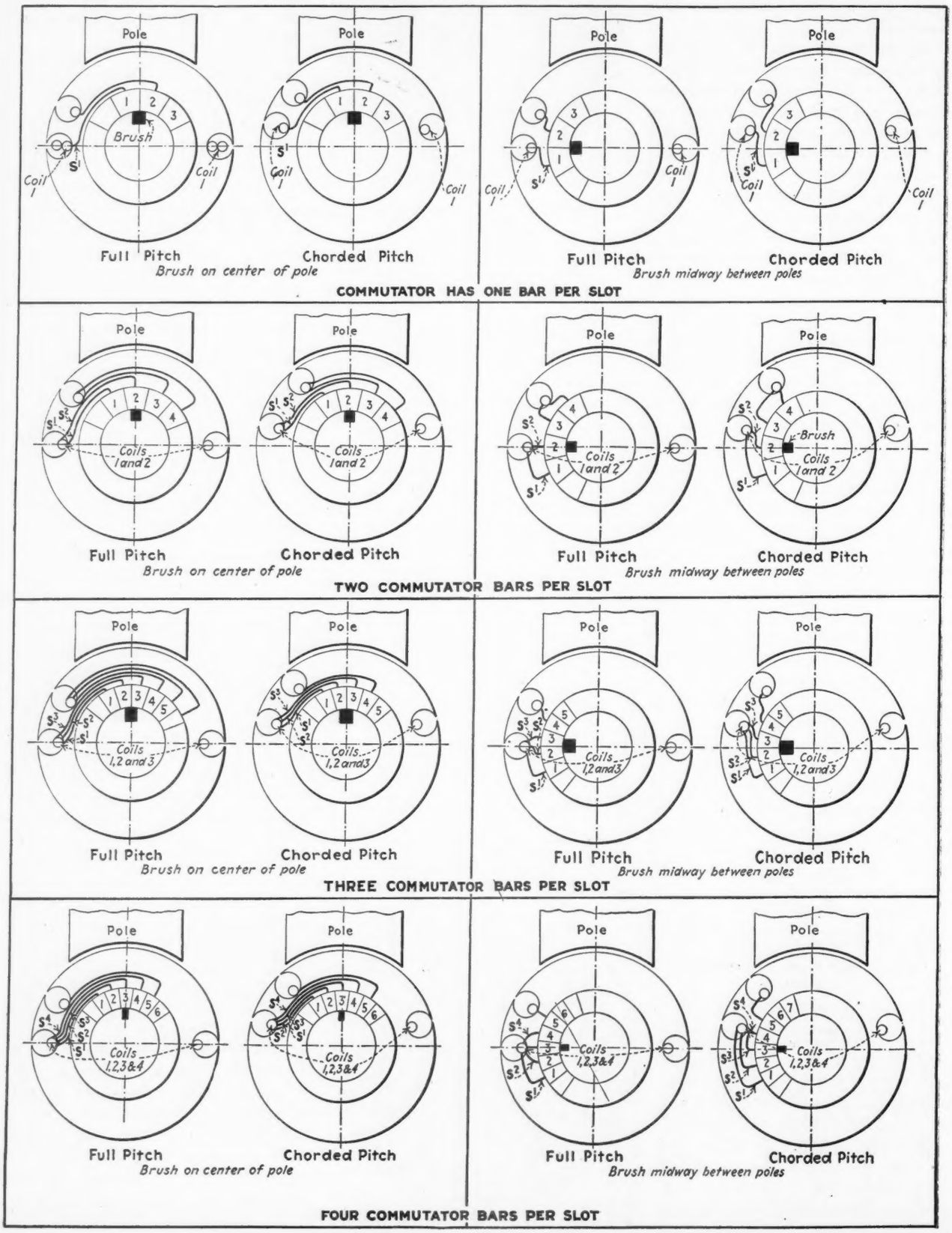
Diametrically Split Winding

In Figs. 6 and 8 is shown a motor wound directly on the half, that is, with full pitch, and from this comes the term "diametrically-split winding." The number of slots must be even for this type of winding, as one half of each coil is wound around the right-hand side of the shaft and the other half around the left-hand side in slots which are exactly opposite each other. Both halves of one coil are in the same slot at the top and in the same slot at the bottom of the armature. As shown in Fig. 8, the first coil is started in slot 1, leaving a white sleeve for a starting lead. Two turns are put in slots 1 and 7 across the right-hand side of the shaft, the wire being put down in layers. Then two more turns are laid down across the left-hand side of the shaft, through the same slots, 1 and 7. After the proper number of turns has been put on, the coil is finished in slot 7 and a red sleeve is left on the finishing lead. One coil fills only half of the slot, and one half the total number of turns per coil are wound on each side of the

shaft. The second coil is started in slot 2, and two turns are taken to the right of the shaft and two to the left, as with the first coil. The second coil starts in slot 2 and finishes in slot 8, as shown in Fig. 8, *C*. The winding is continued in this manner, the start of each coil being always in the slot next to the one where the previous coil was started.

Fig. 7—This shows how the starting (bottom) leads are connected to the commutator.

The four rows of diagrams show the methods used with coils wound respectfively with one, two, three and four wires in hand.



When half the coils are in place, there will be one lead projecting from each slot, six of the leads on one side being starting leads and six on the other side being finishing leads. The top layer is started in the slot which contains the finishing lead of the last coil in the bottom layer. This is slot 7. The winding is then continued as before, and when complete all the slots will be full and each will have a starting lead and a finishing lead. The last coil should be tied down on each side by means of heavy cord threaded underneath the other coils.

Where the Diametrically-Split Winding is Used

This type of winding is seldom encountered as it is more suitable for a few turns of a large size wire, and on most modern motors coils wound outside of the machine are generally used to meet these conditions. However, if it is desired to keep a winding away from the shaft in a machine where the end room is scant, this type is the one to use. The armature shown in Fig. 6 is used in a steam-turbine generating outfit for locomotive headlights. You may notice the hollow space between the winding and the shaft. This was formed by keeping a wooden mandrel on the shaft while winding the armature.

In connecting the split and split-loop windings to the commutator, first, the space between the winding and the back of the commutator is filled in with tape until a smooth bed has been made on which the leads may rest. This bed of tape should be built up to the bottom of the slots in the commutator necks in order to prevent broken leads. After all the loops are cut (in case of a split-loop winding) the bottom (starting) leads are laid down on this bed and inserted in the proper bars, as shown in Fig. 7. The hard part of this is to know where to start the first lead. The diagrams in Fig. 7 show where to start the first lead and the next succeeding lead. By following in regular order, taking up each coil as you come to it, all the leads may be connected entirely around the armature. This drawing shows the methods of connecting for full pitch or chorded pitch and for a brush on the center line of the pole or on the point midway between the poles; also the different parts show how to connect respectively motors with from one to four commutator bars per slot. For instance, the line of drawings just below the top line shows the connection for two commutator bars per slot, in other words, the coils were wound with two wires in hand. After all the bottom (starting) leads are connected to the commutator, then the top (finishing) leads are connected. In order to find out which is the finishing lead of a certain coil, a test lamp is used as shown in Fig. 9. One of the leads from the test lamp is put on commutator bar 1, which is connected to the starting lead of coil 1. Then with the other lead of the test lamp a search is made among the top leads of the coils for the one which will give a light. This one is the finishing lead of coil 1. This is shown as *a* in Fig. 9. Place the finishing leads thus found on the commutator bar next to the right of the one on which the starting lead was placed. In the diagram it is seen that the finishing lead, *a*, is placed on commutator bar 2, which is one bar to the right of bar 1. This can be continued without removing the test lead from bar 1 until convenient, locating the other finishing leads of the coils in succession, placing *b* in bar 3, *c* in bar 4, *d* in bar 5, and so on. When it is desired, the test leads can be removed from bar 1 and placed along further to the right.

In Fig. 9 the bottom lead points to the right, and therefore the top lead of the same coil is put in the adjacent bar to the right. If bottom lead points (*Continued on page 102.*)

Fig. 9—Connecting leads to commutator after the coils are wound.

This is the method for connecting any split, split-loop or diametrically-split winding. The starting leads are laid down in one layer to the proper commutator bars. (See article by Mr. Roe in the January issue of the Electrical Review and Industrial Engineer.) Then the finishing leads are found with a test lamp and connected to the bar just ahead of the starting lead (to the right in this drawing). There is only one slot between the sides of the V, there are twelve slots, and the pitch is 1 and 6.

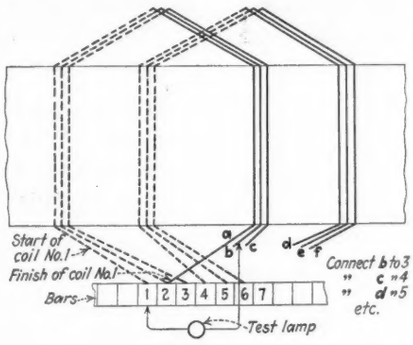
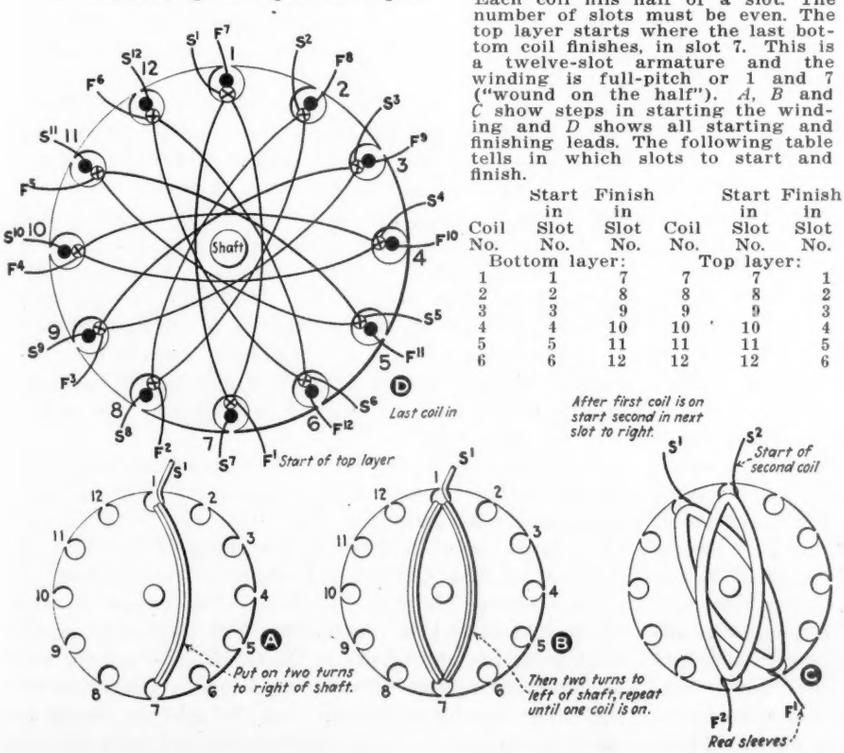


Fig. 8—In a diametrically-split winding each coil is split around the shaft.

Each coil fills half of a slot. The number of slots must be even. The top layer starts where the last bottom coil finishes, in slot 7. This is a twelve-slot armature and the winding is full-pitch or 1 and 7 ("wound on the half"). *A*, *B* and *C* show steps in starting the winding and *D* shows all starting and finishing leads. The following table tells in which slots to start and finish.

Coil No.	Start in Slot No.	Finish in Slot No.	Coil No.	Start in Slot No.	Finish in Slot No.
Bottom layer:			Top layer:		
1	1	7	7	7	1
2	2	8	8	8	2
3	3	9	9	9	3
4	4	10	10	10	4
5	5	11	11	11	5
6	6	12	12	12	6


Shaft
Last coil in
Start of top layer
After first coil is on start second in next slot to right.
Start of second coil
Put on two turns to right of shaft.
Then two turns to left of shaft, repeat until one coil is on.
Red sleeves

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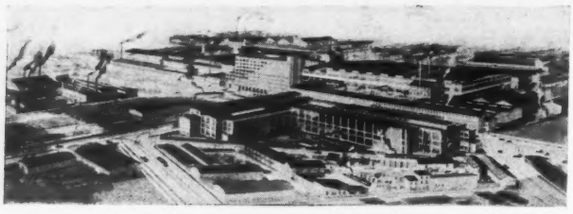


DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT E. H. HUBERT C H. REEDER

Chicago, February, 1922

Know What to Do Before You Start

JUST as a physician must carefully diagnose his case before administering a remedy, the operating man who is responsible for maintenance and repair work must study the behavior of electrical equipment under both normal and abnormal operating conditions. It is not enough to know how to repair a trouble after it develops. It is just as important to know whether the case is in an incipient or a chronic stage when signs of trouble show up. Usually it takes more experience and a thorough knowledge of machine operation to know whether a motor, a crane or some other machine can be kept in operation a few hours until closing time with no serious injury and just what attention it needs during that time, than it takes to find the trouble and take the machine out of service. Knowing just what to do before you start, therefore, is just as important and a little more so than to know how to carry out the details of the repair at the bench.

Start a Repair Handbook

IN THE preface of the first (1895) edition of Prof. Kent's well-known Mechanical Engineer's Handbook, he quotes the suggestion of Nystrom, "Every engineer should make his own pocket-book as he proceeds in study and practice, to suit his particular business."

This advice is just as applicable today as it was some twenty-seven years ago, in the field of repair and maintenance of industrial electrical equipment. Every man who is responsible for this work could without much trouble make a record of test information; the winding details with a sketch of every different type of armature that is rewound, together with the cost in time and materials required; details of electrical failures in apparatus and the steps in repair; lists of troubles and faults as they develop in the same and different machines with an analysis of the causes; records of production with different intensities of illumination. These and many other phases of everyday work supplemented by clippings from the ELECTRICAL REVIEW and INDUSTRIAL ENGINEER and all other sources of repair and maintenance information, would soon result in a handbook of immense value and service, not only as a reference to the compiler, but as a time-saver in answering the questions of his men.

Incidentally, ELECTRICAL REVIEW and INDUSTRIAL ENGINEER would be glad to publish such information and thus present it in convenient form for use in such a handbook. You are invited also to send suggestions on data and information that you would like to secure on particular phases of your work.

The Convenience Outlet Idea in the Works

JUST where the thinking of the installing engineer or designer leaves off and that of the operating man begins is a division hard to make in many electrical installations. In fact, it is more often possible to discover through the changes and extensions later made, that the operating man either had little to say or was not given a chance. In mills and factories the feeder and distribution circuits for the various departments, when carefully studied, show just what not to do in another similar works. And such a study is sometimes a good one, particularly for the operating man to make.

Changes in manufacturing processes and new methods to reduce the production cost of a product usually require rearrangements of machines and corresponding changes in light and power circuits. Where inflexible wiring methods have been installed to make an easy job, and one low in first cost, a large enough outlay in changes during a period of ten years may be called for to justify twice the expenditure at the start. At best, a wiring system that has been revamped by installments several times is a mess, and serves as a glowing example of waste that the operating man should fight against.

The time for the operating man to get in on this problem is when the lighting and power wiring system is being laid out for a new plant. In fact, it should have his approval before the final drawings are completed. In studying his requirements he should insist on the convenience outlet idea that is now being advocated for residence wiring. There are just as many and perhaps more reasons why it should be easy and convenient to use electric service in a mill and factory as in the home, for the whole plan of economical production centers around the convenient use of electric service as the plant grows and departments are added to it or expanded.

It is impossible to foresee all of these changes. The flexible wiring system is, therefore, the only answer. Suggestions for such a system are given in this issue for a large cotton mill in the installing of distribution circuits on the ceiling and running the feeders to motors above, through the floor. The extent of the whole system and the flexibility of the layout from the standpoint of convenience in the location of motors and accessibility for maintenance and repair make this installation worthy of careful study by men in charge of plant operation.

Work That Is More Than a Job

WITHOUT leadership, a crack regiment becomes a mob, aimless and drifting. Likewise, an electrical department which is not organized along definite lines will not function at anything like its possible efficiency.

The fast-growing applications of electrical energy in industrial processes, heating and other uses, together with the host of new appliances which are constantly coming out, is rapidly extending the use of this form of energy. This means that the responsibilities of the men whose duty it is to supervise, operate and maintain the electrical equipment of industrial plants are growing both in importance and number. The proper discharge of these responsibilities cannot safely be left to chance or good intentions.

Individually the members of the electrical department may be very capable, conscientious men, but if they do not have the benefit of intelligent supervision their efforts are certain to be poorly directed. There will be duplication of work at one point and neglect at another.

Production at anything like full capacity demands that equipment be in condition to operate continuously at the maximum efficiency. This in turn requires that equipment receive skilled attention in the way of systematic inspection, early detection of weaknesses and careful repair. Without organization, which means planning of the work, delegation of duties and the maintenance of good records, it is very difficult to insure that equipment will receive the necessary attention. This does not mean tying everything up with a lot of expensive "red tape." It is simply a matter of getting clearly in mind the problems which are encountered and then working out the simplest and most efficient method of solution.

Inside Story of the Incandescent Lamp

IT IS so easy to take things for granted that those of us whose lot is cast outside of the laboratory and model shop seldom realize the immense amount of time and effort spent in perfecting some of the appliances which surround us on every hand and make for our comfort and convenience. A case in point is the incandescent lamp, the history of which is illustrated in the frontispiece of this issue.

At a casual glance this highly useful little article seems simple enough; offhand, it is merely a glass bulb fitted with a screw shell and end cap and enclosing a fine wire filament supported on a slender glass rod. Simple—yes, but it has taken millions of dollars in money and over 40 years of time to bring the lamp to its present state of development.

Working on something which was entirely new and with very little in the way of previous experience to guide him, Edison literally ransacked the earth in search of a suitable material for the filament of his lamp. Carbonized thread, paper and a host of other materials were tried before he decided that bamboo was the best for this purpose.

Imperfect as these first lamps were, judged by present standards, they created a tremendous sensation when they were first exhibited. The price of gas stocks fell in the market, so sure was the general public that the new light would put the gas companies out of business.

Since that day efforts to produce better lamps have been unceasing and fruitful. If the present day lamps had the same efficiency as Edison's first commercial lamp (5.8 watts per candle) the extra coal required at normal prices to produce the electric light used in this country would cost considerably more than half a billion dollars.

This same story could, with some modifications, be written about a great many of the electrical and mechanical devices which come into our daily lives in countless ways. These big and useful things do not just happen, nor does genius or superior ability play as important a part in their development as we sometimes think it does. They are the results of hard work, intelligently directed and backed up by a stout heart which refuses to yield to obstacles that invite weariness and discouragement.

Teamwork Will Always Win

THE need for teamwork, for the all-pulling-together spirit, is greater now than it has been for perhaps many years. There has never been a more thorough upheaval of the established order of things in the business, social and industrial life of the world than that we have witnessed during the past four years.

Now industry and business as a whole are making a slow but definite recovery. On every side there is evidence that better days are coming; more inquiries are being received, more orders are being placed, but there need be no mistaking the fact that the market is pretty largely what is known as a buyer's market. Price and quality are the determining factors.

Buyers are now picking and choosing, and probably will be for a long ime. In other words, the manufacturer who can turn out the desired quality of goods for the least money is the one who will ordinarily get the order; his men will be busy and prosperous.

In the last analysis the ability to produce cheaply and well is in a large measure a matter of teamwork. Individual brilliancy is highly desirable, but no organization, whether it be a ball team or an industrial force, can hope to function at its best unless the various units comprising it work together in sympathy and harmony.

In order to be a star player in the team, you must know your own job and something of the other fellow's, too; you must help him do his work and in turn let him help you. At times you must sacrifice personal aims or advantages for the general good.

Teamwork is not always easily acquired, but it is worth far more than it costs, in effort and sacrifice. It is an elusive thing, powerful and yet easily destroyed. The man who can inspire it is a leader of men, whether he wears a silk hat or overalls. And the plant or the nation which has it need not fear any competitor or enemy.

Thank you Readers!

Your Response Was Great—

But it didn't surprise me a bit

AFTER reading the batch of letters that the editors have received commenting on the January issue of Electrical Review and Industrial Engineer, I could not refrain from saying to them "I told you so." And after some argument, amid blushes of satisfaction and modesty, I managed to beg a little space to present some of the fine bouquets. Naturally I have selected a few of the best ones. There are hundreds of others just as good.

My object is to show the cordial spirit that prevails and how definitely the editors have struck a responsive note among men responsible for the operation and maintenance of electrical systems in mills and factories. I can do this in my official capacity as "Sponsor for the Average Reader" without seeming to be bragging, for as a matter of act, I didn't have a thing to do with the planning of the editorial program except to say it was O. K. and that I was for it one hundred per cent. The way you have backed me up naturally pleases me very much.

But the half of the story has not been told. After you read these abstracts from letters received, just glance at the topics on the opposite page for other articles that are to come.

If you have any comments at any time just drop me a line.

Practical Pete

"The first issue is a dandy."

* * *

"I am more than pleased with it."

* * *

"The first issue was very satisfactory."

* * *

"Your January number cannot be beat."

* * *

"If you continue to publish a magazine like the first issue, well, I am a suscriber *for life.*"

* * *

"I received the *Review* today. Your paper exceeds my expectations. It is first class and full of common sense."

* * *

"Please send me a copy of the January issue if possible, as I don't want to miss any of the articles on armature winding. The last one was great."

* * *

"Your first number is fine and if continued along same lines should be in the hands of every practical worker in the country."

* * *

"Your renamed paper more fully meets the needs of the practical electrician, as his work is largely mechanical as well as electrical."

* * *

"Please send me about a half dozen subscription blanks. I have passed the magazine around the shop. All the fellows like it and would like to take it."

* * *

"I got more good out of that first issue than any book I ever read. It is the real stuff that counts, and you have the real idea. Wishing you a big success."

* * *

"I think your first issue excellent. If it continues so, I shall be a regular subscriber and recommend it to others. Wishing you every success."

* * *

"Your paper is just the thing that the practical man wants if you are going to publish it as outlined in the paper. Please continue my subscription to *Review.*"

* * *

"I feel that you have certainly struck the keynote in publishing a practical journal dealing with electrical and mechanical systems in mills and factories."

* * *

"I like the *Electrical Review and Industrial Engineer* under the new

name and the many good articles in the first number."

* * *

"At last we have found the magazine we have been wanting. It hits the nail on the head in every way and at every angle. I only regret it in a monthly issue."

* * *

"I have read some of D. H. Braymer's work and his name as editorial director is a recommendation of the magazine with me. I congratulate you upon the improvement of your first issue over the old *Review*."

* * *

"It was with much pleasure that I read the new policy of the *Electrical Review*, for I think it will fill a long-felt want among practical men. I shall certainly make an effort to have every man in the shop become a subscriber."

* * *

"The purchase of *Electrical Review* and the editorial plans for the new paper were very interesting to me. There is a large field of service awaits your new paper with the excellent objective which you have outlined and I feel that it will be of as much benefit to me in the position of electrical engineer for a large industrial works as it will be to the trouble shooters and operators."

* * *

"I understand that D. H. Braymer is to be the main guy on what used to be the *Electrical Review*. That pleases me. I had intended to drop out on the expiration of my subscription, but now I will change my mind, simply because I own Braymer's "Armature Winding and Motor Repair," the best book on the subject I have seen, and I own several others."

* * *

"First copy of *Electrical Review and Industrial Engineer* was received with earnest pleasure, mingled, of course, with more or less speculation of what such a publication would present. The breeze that Practical Pete lets out on the first page is a refreshing idea that I am sure will be welcomed by practical men who are in the harness of the everyday grind and responsibility of keeping the wheels turning."

Some Topics That Will Be Discussed

HERE are some of the subjects that will be taken up in articles in the Electrical Review and Industrial Engineer dealing with the problems and experiences of mill engineers and factory superintendents, their assistants and the heads of the various departments in mills and factories.

IN the editorial treatment of articles, practical methods in handling installation work, in repairing equipment and in maintaining continuity of service in existing works, will predominate over the engineering considerations involved in the design and layout of equipment in new buildings. The viewpoint of the supervising operator rather than the electrical engineer will receive first consideration and the paper will talk his language rather than the technical language of the electrical and mechanical engineer.

WHEN the installation of electrical systems in mill and factory buildings is discussed it will be from the standpoint of both electrical and mechanical engineering practice, considering the viewpoint of the supervising head responsible for the inspection and maintenance of the systems involved. The following topics do not represent the actual headings of articles but rather the phases of work that will be discussed.

[1]

Organization of inspection and maintenance departments.

[2]

Practical information and procedure essential in the inspection and maintenance of industrial electrical equipment.

[3]

Scheduling and handling of work in repair shops.

[4]

Procedure in overhauling and remodeling existing systems, both mechanical and electrical.

[5]

Problems in layout and installation changes of lighting and power wiring.

[6]

Details of methods and schemes for handling installation changes in electrical and mechanical systems.

[7]

Practical schemes used in making changes in electrical and its associated mechanical equipment to improve operation, to reduce operating and maintenance costs, to protect men and machines and to formulate standards of practice under different conditions.

[8]

Tests to determine the power requirements of machines in different industrial operations.

[9]

Studies of operating costs and of the apportionment of the cost of electrical energy used in different industrial operations.

[10]

Details of methods of using instruments and tools essential to the making of tests and repairs.

[11]

Analysis of stock keeping methods that are essential to the adequate maintenance of plant equipment.

[12]

Operation and maintenance of special processes that depend upon the successful application of electrical energy, such as heat treating, electric welding, electric furnace applications, electroplating, etc.

[13]

Studies in industrial lighting from the standpoints of maintenance of existing systems and changes to meet the illumination requirements of department processes.

[14]

Analysis of improved operating practices in the handling of materials from their raw state to the finished product.

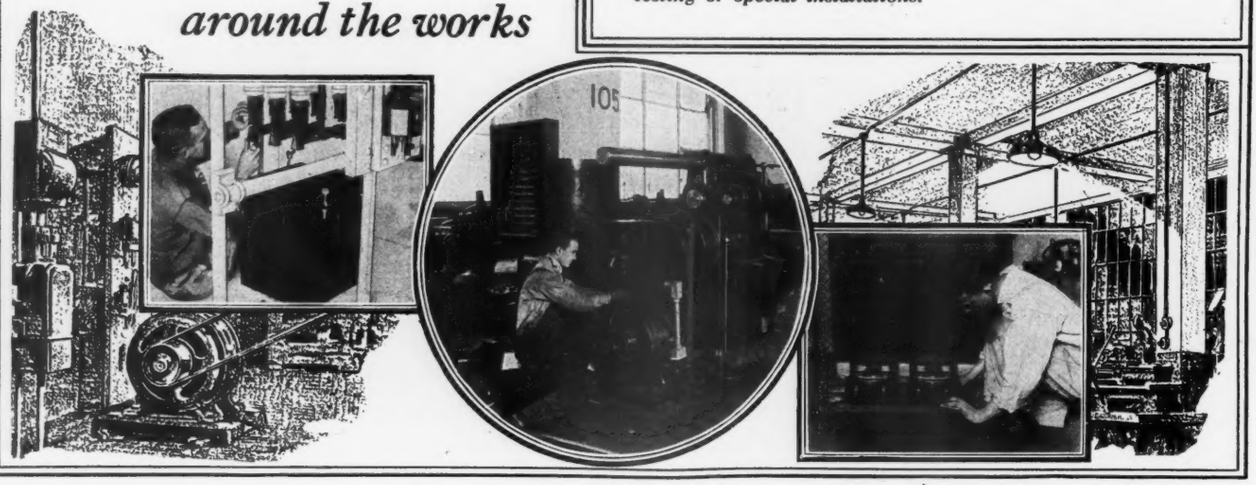
[15]

Analysis of service requirements, testing and maintenance of factory signal systems, such as telephone, fire alarm, watchman and time clock and special call systems.

SERVICE

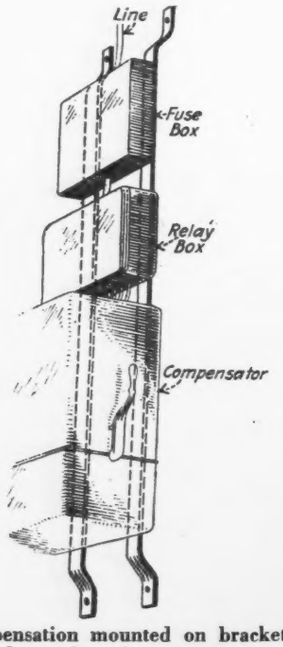
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Compensator Mounted on Strap Iron Support

BY assembling the starting compensator and fuse box on a strap-iron support before putting them up in the plant, the job of mounting or replacing such equipment is made



Compensation mounted on bracket and wired to fuses in shop.

quick and easy in the shops of McCleary, Wallin & Crouse, Amsterdam, N. Y. Furthermore, the various installations present a uniform appearance and tend to increase interest in maintenance. This strap-iron support is of 3-in. x 2-in. material and is about 5½-ft. long. It is drilled to take bolts for holding the equipment which is to be mounted upon it and also for fastening it to walls or pillars in the plant. The compensator, relay and fuse box are bolted to this strap and connections are made in the shop so that it takes very little time to set up the assembled outfit in the plant when it becomes necessary. The box for the fuses is made of No. 16 gage iron and measures 13-in. x 11-in. x 4-in.

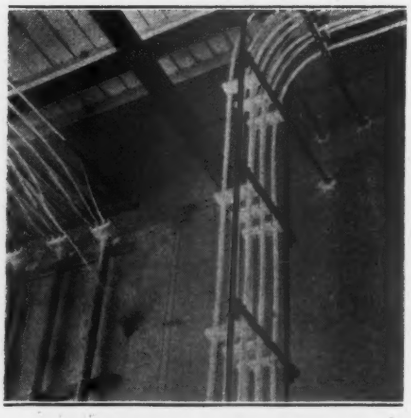
A. R. McDONALD.

McCleary, Wallin & Crouse, Amsterdam, N. Y.

Neat Method of Running Heavy Open Wire Feeders

AN ATTRACTIVE and secure method of running heavy open feeders has been followed in an industrial plant of the Southeast, as illustrated in the accompanying photograph. The feeders are supported upon pipe frames by means of porcelain cleats. The feeders are run three deep along the frame. This type of construction makes a very pleasing appearance and at the same time is safe and strong. The cables shown are 500,000 circ. mil. in size and the supporting frames are of 1¼-in. pipe with standard pipe fittings.

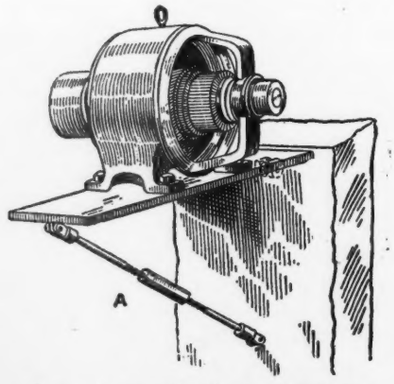
E. H. H.



Heavy feeders are supported on framework made of pipe.

Tightening Short Belts on Individual Motor Drives

TWO methods of tightening short belts of motors mounted for individual drive directly on the driven



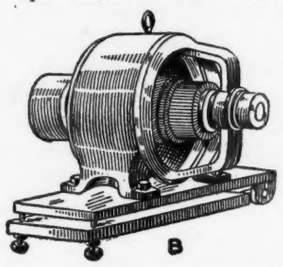
Rod with turnbuckle for tightening belt

machines are employed by the writer. One scheme is to mount the motor on a plate slightly larger than the base of the motor. One end of this plate is hinged and the other is supported on a bar of steel containing a toggle joint with right-hand and left-hand threads (*A* in the drawing). There is a tendency to tip the motor up on one side as the belt is tightened, but the plan has worked very well, and the motor need not tip to any appreciable extent if the belt is kept at about the right length.

In case there is no room for the

use of a toggle joint the motor is mounted on a cast plate and the belt is tightened by the aid of two set-screws in a stationary plate below the one upon which the motor is mounted (see *B*).

If a motor is so placed that it takes takes up valuable manufacturing



Set screws used to tighten belt

floor space, part of the advantage of individual drive is lost, and, on account of the overhead belting required, the same is true if the motor is placed near the ceiling. These objections can be overcome in many instances by mounting the motor on the machine. This means comparatively short centers between driving and driven pulleys, which requires an idler pulley or some other effective yet simple means of tightening the belt such as those described.

Works Engineer,
Canadian Products,
Walkerville, Ont. ALEX. H. MAY.

Energy Requirements in Butt-Welding Steel and Iron Pipe

ELECTRIC butt-welding on steel and wrought-iron pipe has been successfully utilized at the factory of the Whitlock Coil Pipe Company, Hartford, Conn., for about two years. The time required with different currents and voltages and the amount of energy consumed in making welds on various sizes of pipe are shown in the table.

Time and Current Values in Butt-Welding Iron Pipe

Welder	Size Pipe, In., (Ex.Hvy.)	Volts	Amp.	Kw.	Kva.	Duration, Seconds
B	1¼	340	95	25	32.5	50
D	1¼	270	180	42	48.5	38
E	1¼	270	190	42	51.5	34
A	1½	345	160	45	55	46
C	1½	345	170	41	58.5	24
B	2	345	108	26	37.5	120
C	2	330	225	56	74.5	35
D	2½	275	190	38	52.5	220
E	2½	268	200	39	53.5	200
C	2½	320	235	55	75	75
A	3	325	215	54	55	235

It is seen from these figures that the all-important factor, time, is practically dependent on the current alone, higher currents taking less time. It has also been demonstrated in other lines of welding that high currents give the strongest welds. The cost of a typical 1¼-in. extra-heavy butt-weld was 15 cents, including labor, material and energy. By the hand methods formerly used such a job required about three-quarters of an hour against an average of thirty-eight seconds when butt-welding with 180 amp. Another advantage of this method over arc or oxy-acetylene welding is that the original material is used for making the joint. In a number of tensile tests made in these shops on butt-welds locally made the pipe has torn in each case before the weld was damaged in any way.

The butt-weld is made by cutting a female scarf in each pipe end. The ends are then pressed together under an oil pressure of five tons while the current is passed through the joint. As the current heats the ends to be welded, the scarfed portions are thrust outward and the area of the weld is increased over the annular area of the pipe. The inside is not constricted or reduced, but is left smooth and clean. The only objection is that the pipe is increased in outside diameter at the weld, which makes it impossible to use the weld on spiral and other coils made on a former shaped to fit the ordinary outside diameter of the pipe. Where it is essential to secure a weld without reduction of bore or enlargement of outside diameter, lap-welding with a mandrel is employed.

G. T. JACOCKS

Whitlock Coil Pipe Company,
Hartford, Conn.

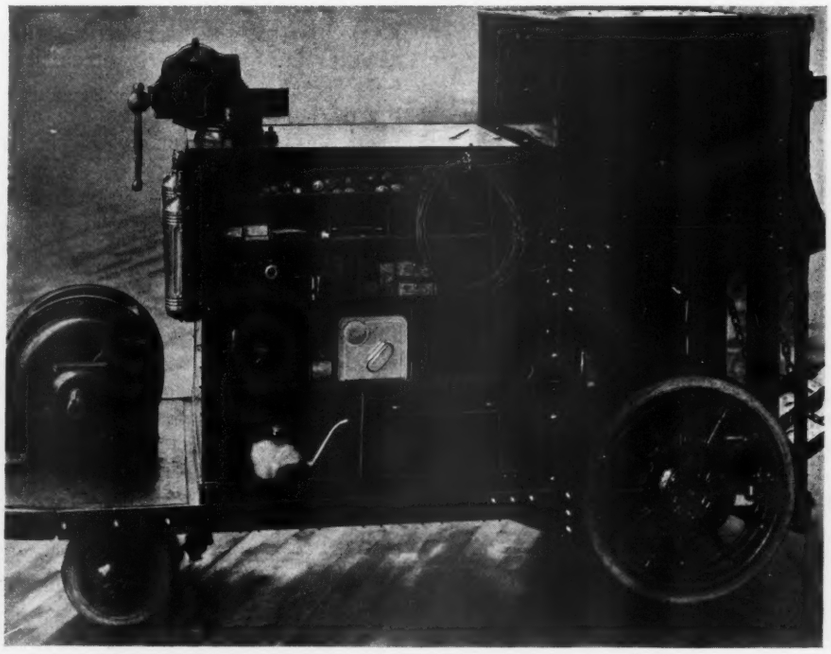
Motor-Repair Trouble Wagon

TO REDUCE the periods of shut-down, a portable repair wagon for maintenance of the motors and other electrical apparatus has been developed in the Detroit factory of the Central Gear Company; where 700 motors are in operation. In case any motor trouble develops or is indicated, the foreman of the department calls the wagon by pushing the button on any pillar, thus operating an annunciator in the repair shop. The wagon, which is a modified industrial truck, painted red to compel attention and secure right-of-way, is equipped with a bench, a vise and everything that experience has shown to be necessary in making quick repairs to motors. With two or three exceptions the motors used in the plant are only up to about 15 hp. in size, and if a motor has to be removed there is a platform on the truck on which the motor or compensator, or both, can be carried to the repair shop and a new motor brought back.

The extent of the plant is, roughly, 600 ft. x 360 ft., but the truck can get to the farthest point one minute and a half after it has been called. There are always men in the repair department, so if the truck is out when a call comes someone goes on foot.

A motor-repair shop on wheels.

This repair wagon is equipped with virtually everything necessary to correct the troubles usually found in motors, controllers, lamps, wiring and conduit. A trouble call brings the repair wagon to most parts of the plant in a minute or less.



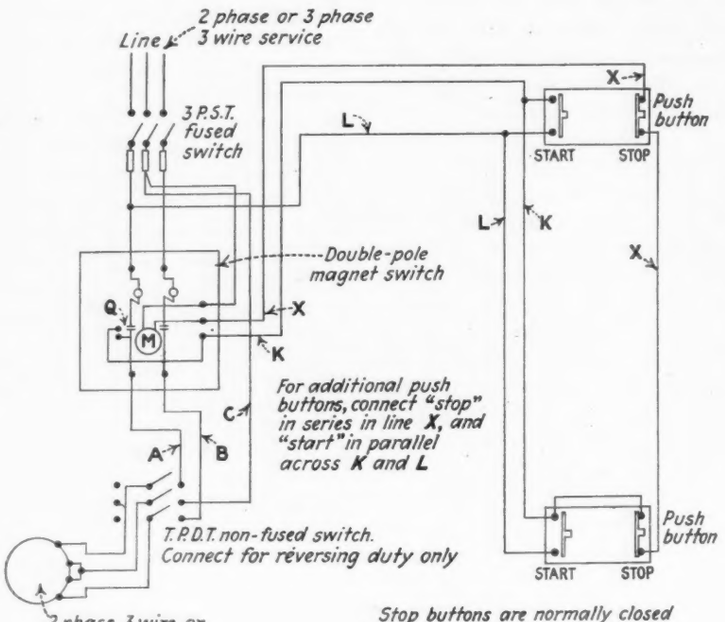


Diagram for remote control of small motors from more than one point.

Remote Control of Motors on Hoists Increases Safety of Operation

TO INCREASE the safety of operation of hoists remote push-button control is in use at the Brooklyn Bridge fish-freezing and cold-storage plant in New York City and the French government fish-freezing plant at St. Pierre, Miquelon. The "stop" and "start" buttons are placed at the various points where the hoists are loaded or unloaded, so that any of the operators can instantly shut down the hoist if anything should go wrong. Both buttons are contained in one case (a standard Cutler-Hammer D-5 push-button switch) and operate a Cutler-Hammer magnet switch of the double-pole type which is indicated in schematic form in the drawing at the left of the center.

The diagram shown is for remote push-button control of motors of 5 hp. and under, which can be thrown directly across the line. For use with larger motors a magnet switch with motor-starting resistance must be used in place of the double-pole magnet switch shown. However, 7½ hp. motors can be used with the apparatus as shown on the diagram, provided that there is a separate power circuit available and that there are no electric lights connected to this circuit.

The principle of operation is as follows: When a "start" button is closed the circuit to the coil *M* is closed. When the switch closes the auxiliary contacts *Q* on the switch keep this coil circuit closed so that the starting button in the circuit can be released.

All the "start" buttons are connected in parallel and are normally open. The "stop" buttons are normally closed and are all connected in series with the magnet coil *M*. When the "stop" button is pushed this opens the circuit to the magnet coil *M* so that the switch opens. When the switch opens, the auxiliary contacts *Q* also open so that when the stop button is released the circuit of the magnet coil *M* remains open until a "start" button has been again operated.

The reversing switch as shown is for use at times when it is necessary to operate a hoist in the reverse direction.

EUSTACE C. SOARES.

Electrical Engineer,
Ophuls, Hill & McCreery, Inc.
New York City.

Pull-Out Force Determines Right Motor Size for Saw

THE majority of wood and metal saws are used intermittently and therefore the motors are not likely to become overheated on account of underrating. However, a motor must be obtained with a sufficiently high pull-out force to carry the maximum load required.

This requirement was found in a veneer mill to be especially important where it was estimated that it would take a 48-in. circular saw about ten seconds to cut through 12-ft. logs, and that the power required would be 120 hp. The motor recommended for this use was a standard 40-hp., three-phase, 60-cycle, 220-volt motor with a pull-out force of three times full-load torque. The test on the motor soon after it was installed showed the following results:

Test No.	Input, Kw.	Output, Hp.	% Power Factor	Remarks
1	1.8	.....	14.5	Motors only
2	4.8	4.02	32.0	Motor 48-in. saw
3	44.8	57.64	73.0	
4	73.2	95.7	81.6	Ripping 15-in. by
5	96.8	127.0	83.5	12-ft. logs in 9 sec.

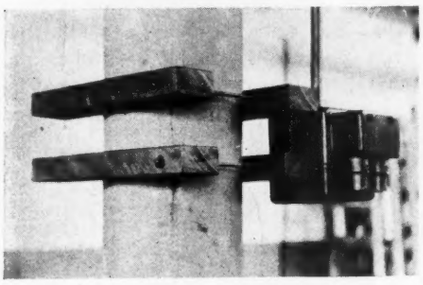
The logs were mounted on a positive feed carriage and ripped into boards. The maximum load of 127 hp. shown in the test was obtained when the saw was ripping through the center of the log. This is as heavy a load as the motor is called upon to carry. Sixty-inch saws are sometimes used and are often embedded practically up to the hub. The speed of the carriage is then necessarily reduced, however, and the amount of power taken is no greater than that shown above. The direct connection of the motor to the saw shaft was considered, but the saw sometimes meets with obstructions in the logs, and a belt drive was considered to give greater flexibility. The motor is protected by an oil switch equipped with inverse-time-element overload relays.

New York City. A. M. B.

Method of Mounting Four Starting Switches on One Column

BY MEANS of four strips of wood bolted to the column, as shown in the accompanying illustration, four Westinghouse No. 815 starting switches are mounted on one column in the East Springfield factory of the Westinghouse Electric and Manufacturing Company.

The switches are fed through conduit, which runs from above. The four strips of wood, 2 in. x 4 in. x 19 in. in size, are placed 3¾ in. apart vertically, and 8 in. horizontally. Horizontal tie rods about ⅜ in. in diameter pass through the ends of



Method of mounting four starting switches upon one column.

each strip to hold them firmly to the column. The inside edge of each strip is slightly rounded to fit the column in order to give the strip a better seat.

List of Material Used in Constructing Lighting Switchboard

This board is built for four 200-amp. and four 100-amp., 110/220-volt switches. Space left for four more switches.

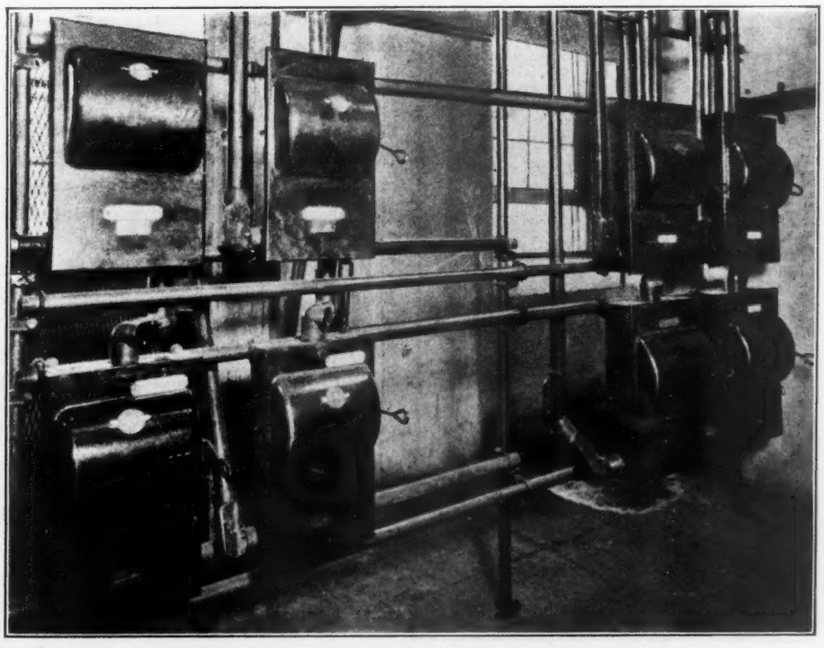
Five pieces 1¼-in. black iron pipe, 10 ft. long.
Three pieces 1¼-in. black iron pipe, 8 ft. 6 in. long.
Two pieces 1¼-in. black iron pipe, 5 ft. long.
Three pieces 1¼-in. black iron pipe, 3 ft. long.
Three No. 225,654 pipe flanges, 1¼-in. pipe, W. E. & M. Co.
Forty No. 112,878 pipe-mounting brackets, complete with ⅝-in. mounting bolts, for mounting switches and conduit hangers.
Three ⅝-in. U-bolts.
Nine No. 238,467 bus supports, 1¼-in. pipe mounting.
90 ft. ⅛-in.x2-in. copper busbar.
Three No. 196,398 busbar terminals for 500,000 circ.-mil cable.
Twenty-four No. 196,397 busbar clamp terminals for No. 4/0 cable.
Four No. 56,353 100-amp., 250-volt fused-bottom "Square D" switches, with end plates.
Four No 56,354 200-amp., 250-volt fused-bottom "Square D" switches with end plates.
Two No. L.B.-66 condulets with No. 600 covers.
Six No. L.R.-66 condulets with No. 600 covers.
Four No. A.-6 condulets with No. C.F.-63 cov-
Six No. L.R.-55 condulets with No. 500 covers.
Four No. A.-5 condulets with No. C.F.-53 covers.
90 ft. No. 4/0 rubber-covered, double-braid, 600-volt stranded wire, connecting 200-amp. switch to bus.
90 ft. No. 1 rubber-covered, double-braid, 600-volt stranded wire, connecting 100-amp. switch to bus.
75 ft. 500,000 circ.-mil, 600-volt cable, connecting 200-amp. transformer to busbar.
Two No. E.-8 condulets with No. C.F.-83 covers, transformer to busbar.
One No. C.-8 condulet with No. C.F.-83 covers, transformer to busbar.
One No. 3conduit elbow, transformer to busbar.
8-ft. 3-in. conduit, transformer to busbar.
Two pieces 2-in. conduit, 6 ft. long, switches to busbar.
Two pieces 2-in. conduit, 2 ft. long, switches to busbar.
Four pieces 2-in. conduit, 4 ft. long, outgoing lines.
Four pieces 1½-in. conduit, 4 ft. long, outgoing lines.
Two pieces 1½-in. conduit, 6 ft. long, switches to busbar.
Two pieces 1½-in. conduit, 2 ft. long, switches to busbar.
Six ⅜-in.x4-in. U. S. expansion shields and bolts.
Eight 2-in. conduit lock nuts.
Eight 1½-in. conduit lock nuts.
Eight 2-in. conduit bushings.
Eight 1½-in. conduit bushings.
50 ft. 500,000 circ.-mil waterproof, three-braid cable, for grounding neutral bus.

LABOR—Two electricians and one helper about twelve days of eight and three-quarter hours.

Safety Lighting-Feeder Switchboard for Industrial Plant

A SUBSTANTIAL switchboard for lighting feeders was built recently in a Pennsylvania industrial plant of iron pipe and safety switches. This is a 110/220-volt board with eight switches and is supplied from two 50-kva. transformers. The switchboard frame is made up of 1¼-in. iron pipe with standard malleable-iron mounting brackets. The switches consist of four three-pole, 220-amp., 250-volt fused-bottom switches (shown on the right) and four 100-amp. switches of the same kind (shown on the left), with sufficient room left between them to mount four more switches when additional circuits are required. The copper busbars are carried on porcelain bus supports mounted on top of 1¼-in. pipes, which run from the top of the frame to the wall as braces, and connections from the top of the switches to the bus are run in conduit.

Pipe framework supports safety switches for lighting feeders



Conduit runs directly from the tops of the top switches to 6 in. under the bus, where the wires are shaped for connection to the bus with standard bus-terminal clamps. Conduit runs from the top of the lower switches with an "L.R." and "L.B." condulet to turn the conduit up back of the top switches, each conduit having an "A" condulet at top with three-hole composition cover. The 200-amp. switches have 2-in. conduit with two No. 4/0 cables and one No. 2/0 cable to each switch. The 100-amp. switches have 1½-in. conduit with two No. 1 cables and one No. 4 cable run into each of the switches.

The distributing conduits are all brought out on the left-hand side at the lower corner of the switch, with "L.R." and "L.B.B." condulets next to the switches. Conduit is run up back of the switches and structure and distributed to various places, part running out underground and part overhead.

The accompanying table shows the list of material for the board.

Swissvale, Pa. F. W. McGRAW.

Care of Electrical Instruments

THE great majority of repairs on electrical measuring instruments are necessary because of two or three things which may have happened. The most common cause of failure of electrical instruments is the burning out of the hairsprings which control the action of the moving coil and also carry the current. This, of course, applies only to direct-current or dynamometer type instruments. Such instruments will usually stand an overload of several hundred per cent, but when an ammeter is connected in as a voltmeter, or some similar mistake is made where the current flowing is a great many times normal, it is usually the hairsprings which burn out first. There have been many attempts to put fuses in instruments to protect them against this sort of a burn-out, but they have not as yet been very satisfactory, and general practice is against their use. Of course burnouts of this sort are due to carelessness, and it merely takes a little thought before using an instrument in a circuit to eliminate this sort of accident. Where an instrument is put into a circuit and it is not known what current or voltage exists, an instrument of such a high range should be chosen for the first test that there will be no possibility of overloading it. The reading on the high-range instrument can then point out the proper range to be used for accurate reading, if the reading itself is low on the higher range.

It is a good rule to think twice before putting an instrument on any circuit and to check, if possible, the capacities which will be necessary against what is expected in the circuit. For instance, in testing a 50-hp., 440-volt, direct-current motor an ammeter of 100 amp. full scale should be used at the start, and this should preferably be short-circuited with a heavy knife switch during the starting period; then if any heavy load comes on the motor, causing it to take full-load current, the ammeter will not be burned out.

The moving elements of all instruments are swung on hard steel pivots resting on polished sapphire jewels. The bearing pressures on these pivots run quite high, and a little figuring will show them to be of the order of several thousand pounds per square inch. As might be expected, a severe jar or a drop of several feet on a hard floor will cause these fine steel pivots, resting against the hard jewels, to bend or flatten and perhaps break off if the material is too hard to stand up properly. The net result of this is an increase in the friction of the instrument, which, of course,makes it unfit for use where fine readings are to be taken. The only remedy in this case is to replace the pivots.

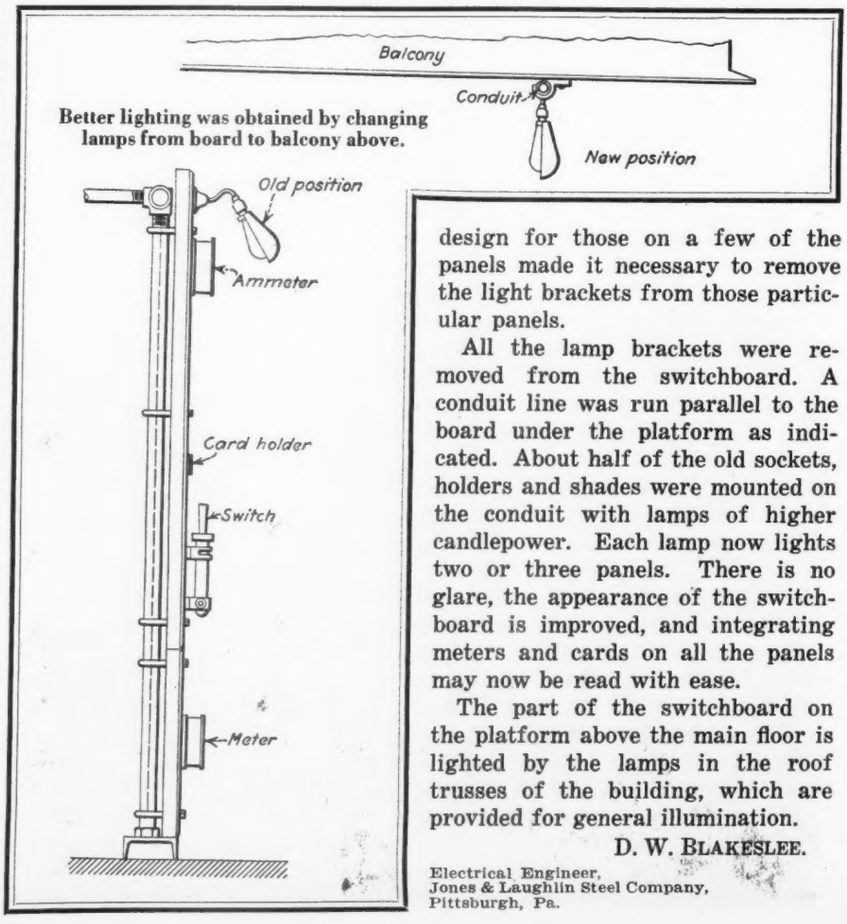
Care should be taken that instruments are not dropped and that they are not subjected to jars. For instance, no hammering should be done on a bench on which instruments are standing, as the jar from this will cause the pivots to flatten and increase the friction error of the instrument.

Instruments should not be opened by the user. Almost all commercial instruments are now sealed with a wax or lead seal, and if this is broken the responsibility rests with the user and he is always charged for repairs. If the seal is unbroken, the manufacturer then knows that he has only overloading and rough handling to contend with and can proceed accordingly in the repair of the instrument.

JOHN H. MILLER.
Electrical Engineer,
Jewell Electrical Instrument Company,
Chicago, Ill.

Lamps Mounted on Ceiling Light Switchboard Satisfactorily

BETTER lighting of a switchboard in an industrial plant was obtained by changing the position of the lamps from a bracket in the board to the ceiling overhead. The feeder panels of the switchboard were originally each provided with bracket lights, which were mounted near the top of the panels beside the circuit breakers, as shown in the accompanying drawing, for illuminating the indicating ammeters. With the lamps on the switchboard there was some trouble from glare due to reflection on the glass in the ammeters and also because a part of the lamp bulbs were in the direct line of sight of a man near the board. The substitution of circuit breakers and ammeters of different



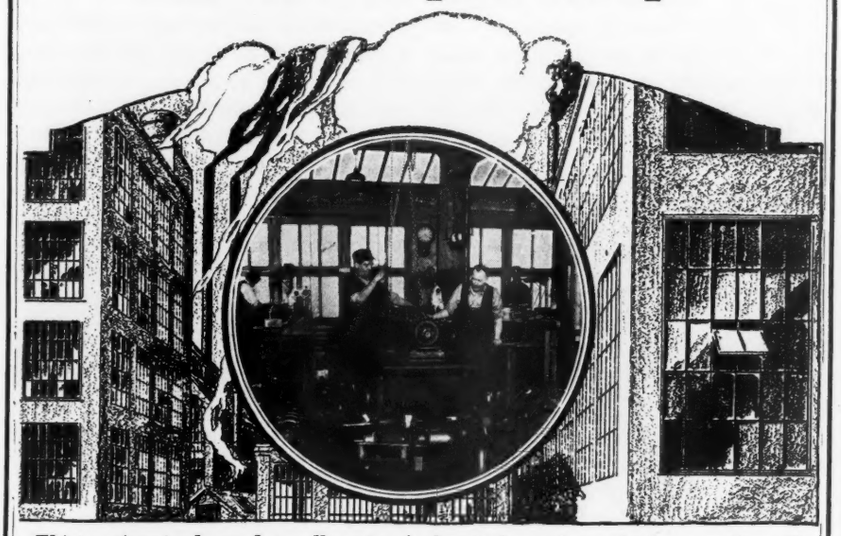
design for those on a few of the panels made it necessary to remove the light brackets from those particular panels.

All the lamp brackets were removed from the switchboard. A conduit line was run parallel to the board under the platform as indicated. About half of the old sockets, holders and shades were mounted on the conduit with lamps of higher candlepower. Each lamp now lights two or three panels. There is no glare, the appearance of the switchboard is improved, and integrating meters and cards on all the panels may now be read with ease.

The part of the switchboard on the platform above the main floor is lighted by the lamps in the roof trusses of the building, which are provided for general illumination.

D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Steel Company,
Pittsburgh, Pa.

In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Rewound Motor for Testing Phase Rotation

FOR checking phase rotation an eastern repair shop rewound a 1½-hp., three-phase, 60-cycle, 220-volt, 1,050-r.p.m. motor to two-phase, 440 volt, twenty-four poles, 265 r.p.m., as the lower speed was better for observing rotation and the two-phase connection permitted of testing both two-phase and three-phase lines. To assist further in noting direction of rotation a white arrow was fixed to the end of the shaft and a black disk mounted behind the arrow on the end frame, the direction in which the white arrow slowly revolved in front of the black disk being easily observed.

The motor had forty-eight slots and a coil pitch of 1 and 7; it was connected series-star, each coil being wound with twenty turns of two No. 19 single-cotton and enamel-covered wire. The six-pole pitch of 1 and 7 chorded has a chord factor equal to sin $(7 \times 180/8)/2 = \sin 78° 0' 45'' = 0.9807$. Full-pitch line voltage should be $220/0.981 = 224$ volts per phase, or $224/1.73 = 129$ volts star. This winding will then be good for $(3 \times 129)/2 = 188½$ volts for two-phase series connection. The number of turns per coil required for two-phase, 440 volts, twenty-four poles, is $20\ (440/188.5) \times 24/6 = 186$ turns for full pitch. The turns being increased 9.3 times, the cross-section of copper was decreased in the same proportion, the size nearest correct being No. 25; but as the proper number of turns of No. 25 more than fill the slots, No. 27 was used. As rewound, the motor had forty-eight coils (two-layer winding), pitch 1 and 3, and was connected series, one coil per group, and developed approximately 1/3 hp.

The motor was mounted on top of the testing switchboard with the dial facing the test bench, and four wires were brought down to four plug switches, a fuse being placed on each outside wire between the test motor and the plug. The plugs were arranged A1, A2, B2, B1; for three-phase tests a lug was used at the back of board to connect A2 and B2 together. A 6-ft. length of cable is used for each test lead, the male end of the plug switch being attached to one end of the cable and a bull-dog testing-clip to the other end. This phase rotation tester has been in use for about a year and a half and has proved a valuable instrument.

Detroit, Mich. A. C. ROE.

Reconnecting a Two-Phase Motor for Three-Phase Operation

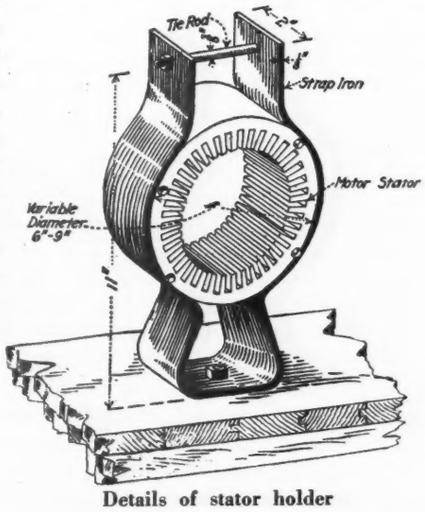
BY REWINDING a burned-out two-phase, 220-volt motor with twice the number of turns per coil but with wire of half the original cross-section the motor was prepared for easy reconnection to three-phase, 550-volt operation later. The motor was 5 hp., 60 cycles, 1,700 r.p.m., four poles, and had forty-eight slots and twenty-four coils, one coil per slot, connected as a basket-type winding. Each coil originally consisted of twenty-two turns of two No. 14 double-cotton-covered wires in parallel with the coils in series for 220 volts, two-phase. The pitch was 1 and 10.

As a two-phase motor has approximately 25 per cent more turns than a three-phase motor of the same voltage, and as 550 is 25 per cent more than 440, it follows that the windings of a 440-volt, two-phase motor are equivalent to a 550-volt, three-phase motor. This motor was therefore rewound for two-phase, 220-volt parallel operation, or two-phase, 440-volt series operation, by winding the coils with forty-four turns of No. 14 double-cotton-covered wire, which was twice the previous number of turns and half the conductor cross-section. The same coil pitch was used. C. A. JOHNSON.

Bronx, New York City.

Stator Holder for Motor-Winding Shop

TO FACILITATE holding motor stators during rewinding at the shop of the American Electric Service & Maintenance Company, Springfield, Mass., a flexible metallic holder which consists of a piece of strap-iron is used. The strap-iron is about



Details of stator holder

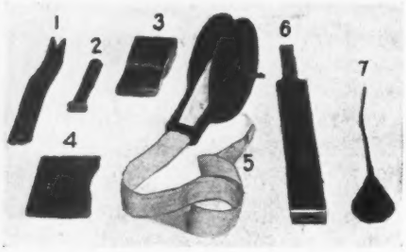
28 in. long, bent into the shape of a U-clamp, with the upper ends held in place by an adjustable rod and bolts. The lower end is bolted to the bench and the whole outfit forms a springy receptacle which can be adjusted to a wide variety of motor frames ranging in diameter from

6 in. to 9 in. The strap-iron of which the holder is made is 2 in. wide and ⅛ in. thick; the tie rod at the top is ⅜ in. in diameter, and a ⅜-in. bolt fastens it to the bench. It stands about 11 in. high.

Home-Made Tools for Electrical Repair Shop

AT THE repair shop of the American Electric Service & Maintenance Company, Springfield, Mass., the set of home-made tools illustrated herewith is used to facilitate rapid work. These devices are as follows: (1) Paper cutter, (2) wedge driver, (3) wedge driver, (4) tapered slot or lamination straightener, (5) tape reel, (6) wedge driver and (7) tape hook.

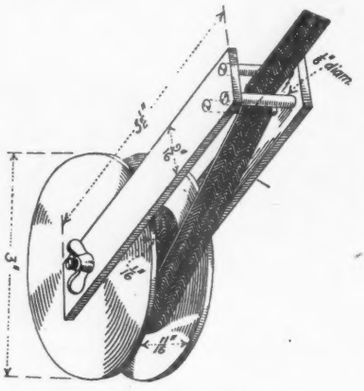
The paper cutter (1) is 6 in. long, ⅝ in. wide and 1/32 in. thick, with a slight offset in its central portion



Tools used in motor repair shop

to facilitate prying and a V-shaped slot at the end to enable protruding paper to be easily cut down to the slot level. The wedge drivers (2 and 3) are of convenient shape for work within the stator frames of motors and generators, and the tapered slot or lamination straightener (4) is a handy tool 4 in. long, 2 in. wide and ⅜ in. thick, with tapered surface from right to left, making it more convenient to smooth out slot interiors before applying the coils. The tape reel (5) provides an easy means of keeping tape out of the way when working around the bench, the brass circular sides being 3 in. in diameter and provided with a U-shaped clamp with rods at the upper end through which the tape is fed. A wing screw enables the movement of the reel to be adjusted for the friction required to pull out the tape. With this reel enough tape to handle the immediate requirements of the job is fed forward.

The wedge driver (6) is essentially an extension hammer which fits into a slot and which can be forced forward from without in such a way as to bring effective working pressure upon tightly embedded wedges in order to remove them or force them into final position. It consists of a ½-in. x ⅛-in. steel tongue running in a holder bar 9 in. long.



Details of handy taping reel

The tongue is driven forward by placing a driver bar in the tool and hammering from the outer end.

The tape hook (7) is 5 in. long with an additional 1¼-in. bend at the end and is convenient in handling tape and other materials of this nature.

Cutting Fiber to Narrow Widths

TO CUT fiber in very narrow widths the American Electric Service & Maintenance Company, Springfield, Mass., designed the home-made gage illustrated herewith for attachment to a paper cutter. The gage consists of a straight bar, 21 in. long, 1¾ in. high and 3/16 in. wide, attached to angle pieces which are seated against two sliding blocks arranged to move back and forth, as required, on the regular stop of the cutter. A ½-in. rod connects the sliding blocks and is fitted with a spring to hold the gage in a horizontal position parallel to the face of the cutter. The gage can be fixed in any position along the cutter by set-screw adjustment, and the fiber can be cut to hair-widths if desired.

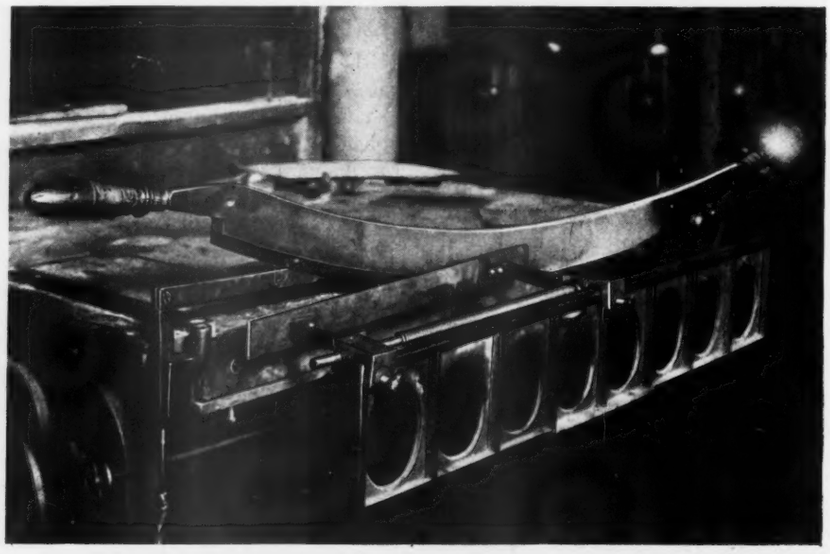
K. KNOWLES.

Boston, Mass.

Handy gauge and knife for cutting insulation for armature slots

Block for Insulating Coils Before Placing in Motor

FOR tying slot insulation on to coils before they are put into the slots of motors or generators, a wooden block such as shown in the accompanying illustration has been made by the writer. This block enables the insulation to be wrapped snugly around the coil and tied so that it will not be loose when the coil is taped. To use the device, the insulation is cut into strips just wide enough to make about a turn and a third around the coil. A strip is placed in the long groove, which is just the shape of an armature slot. The coil is put in on top of the strip and the overlapping insulation is folded over. The two slotted metal pieces are then slipped over the insulation and are held in place by two screws as shown. Then the insulation is tied around the coil by threading a length of twine underneath the coil through the small



slots by means of a curved sack needle. If it is desired, tin clips may be used for holding the insulation in place instead of tying it with the twine. The writer has tried several methods and prefers to tie with the twine.

A further purpose of this device is to indicate the position on the coil for the cotton sleeving emerging from the tape. This is

Insulation is held under slotted bars while being tied in place.

done by marking the position on the base of the device at the point indicated by the arrow where a line is painted. When the coil is placed in the groove a blue pencil mark is drawn across the coil, thus indicating to the taper where to bring out the sleeving. As a usual thing about 1 in. of the sleeving is taped in.

Such a device is cheap and easily made and a separate one is used for each size of coil. L. E. WOOD.

Glasgow, Scotland.

Portable Stand for Holding Armatures

BOTH large and small armatures can be accommodated by the portable armature stand shown, which is in use in a large motor-repair shop in New York. This stand is made of timbers fastened securely together and slotted to receive the armature shafts. Strong casters at each corner of the base make it an easy matter to move the stand anywhere in the shop. Besides being used for holding armatures of motors whose stators are being repaired, the stand is handy for supporting armatures to which air-drying varnish has been applied.

New York, N. Y. W. A. HARRIS.

Systematic Care Insures Service from Storage Batteries

UNDER fair treatment and conditions a storage battery will give excellent service. A system of taking care of batteries used on vehicles of the United Dressed Beef Company, New York City, has resulted in greatly increasing the life and the mileage of batteries in this establishment. Operating from one station of this company there are twenty-eight vehicles working six days a week and about twelve hours a day. Extra sets of batteries are kept on hand for substitution in case of trouble and at the regular overcharge and inspection every three months.

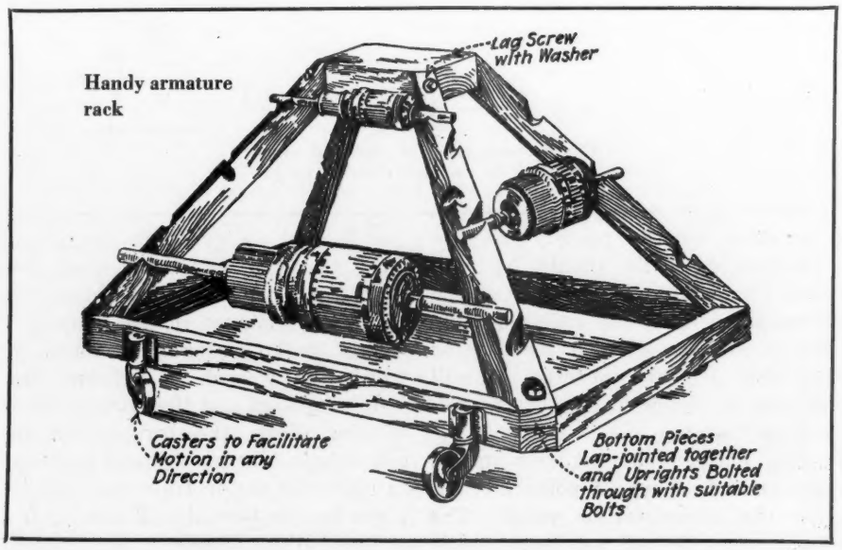
A careful schedule for routine work is followed. The battery is charged every night at a constant rate and at a specified current until gravity is up to standard, about six to seven hours. Reports are handed in daily showing the results of the charge, the mileage of the truck, the flushing of the battery and any trouble which has been noticed by either driver or charger. Once a week each battery is flushed, the tops of the cells and the connections are cleaned and dried, and the terminal connections are oiled. At the same time an overcharge is given for four hours at 12 amperes. Once every three months the battery receives a special overcharge and the specific gravity is equalized. The charge may last from twenty-four to thirty-six hours at a rate of 8, 10 or 12 amperes. The specific gravity in each cell is adjusted to 1.285. This charge may be stopped when the acid stops rising in gravity if this gravity is 1.280 to 1.285 and the battery voltage is normal.

After a battery has given ten to twelve months of service it is taken apart, the cells are cleaned and the entire battery is overhauled. Then the battery is put back in service until it is in a condition to be junked. The cells are then opened, the acid is thrown away, the sediment is saved in a large tank, and the lead, jars and tray handles are stored in bins. The straps and connectors are melted over for new straps and connectors, the old plates are sold, and the handles are saved to be used again.

In the daily treatment as soon as the car is placed in the garage the side doors are taken off to allow complete ventilation of the batteries. Before the charge is started a voltage reading with the battery on open circuit is taken. From irregularities in this reading a number of troubles can be located.

After the voltage reading is taken the battery is put on charge. Charging rates for each car are posted in the switchboard room. The open voltage readings and the voltage and current readings which are taken hourly are then recorded on a battery charging slip. At the end of the charge the temperature of the battery is noted and the specific gravity of the pilot cells is taken and added to the information on the slip. The slip is then handed in to the man in charge of the battery department. By inspection of these slips he can tell fairly well the condition of the battery.

Every three months, as stated, the battery is taken out of the car, an extra battery substituted, and a long overcharge is given. The battery is then equalized, after which it is discharged at its normal rate. Readings of voltage and specific gravity

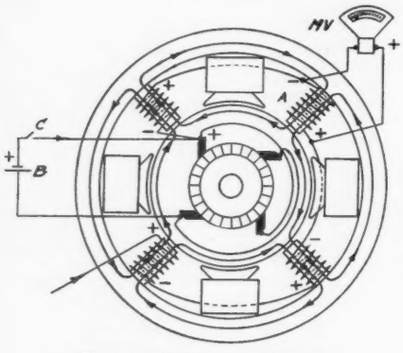

Handy armature rack
Lag Screw with Washer
Casters to Facilitate Motion in any Direction
Bottom Pieces Lap-jointed together and Uprights Bolted through with suitable Bolts

are taken hourly at each cell. If there is any trouble present, it will be discovered by this test.

ARTHUR F. CAMPBELL.
Foreman Battery Department,
United Dressed Beef Company,
New York, N. Y.

Inductive Test for Polarity of Commutating Poles

WHEN a D. C. motor or generator is assembled after repairs have been made, or when changed from motor to generator or vice versa, there is sometimes doubt as to the proper relation between armature and commutating-pole connections. The serious sparking that



Positive deflection of meter shows that commutating coils are properly connected.

would result if the commutating coils were reversed makes it very desirable to be sure of the connections before placing the machine in service. The following method of testing for proper connections has been found to be simple and reliable:

Trace the relative direction of current through the commutating field and the armature, which is conveniently done by assuming that current enters the machine, passing first through the commutating-field windings and then through the armature. Call the lead through which current enters any coil, positive, and the brush through which current enters the armature, positive. Connect the positive terminal of battery *B*, which may consist of one or more dry cells, to the positive brush, and the negative battery terminal to the other brush, leaving the circuit open at any point, *C*. Connect a millivoltmeter, or a shunt ammeter without the shunt, across any commutating-pole coil that happens to be most convenient, as *A* in the sketch, with the positive meter terminal on the positive lead of the coil.

Complete the battery circuit at *C*, and then suddenly open it, observing the direction of meter deflection at the time of opening. If the commutating field is connected in the proper relation to the armature the deflection will be positive. If there is any doubt about the relative polarity of individual coils in the group, repeat the test on other coils, or on all coils, if necessary, to remove the doubt. However, the winding of commutating poles is usually so open that it is easy to establish the relative individual polarity by inspection. If the relative individual polarity is correct and any coil gives negative deflection with the above test, the obvious remedy is to interchange the connections of the commutating poles as a group.

One dry cell will usually be sufficient to give a deflection that can be observed with certainty as to direction, but if necessary to add more cells they should be connected in parallel, because the armature resistance is so low that the battery current is limited largely by the internal resistance of the cells, and therefore adding cells in series would not appreciably increase the current through the armature.

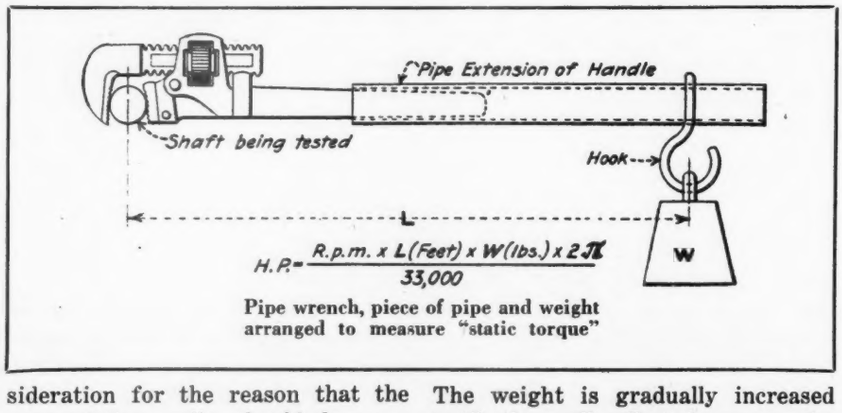
It will be seen that the direction of rotation, the polarity of main-field poles, the kind of armature winding, and the question of whether the machine is operated as a generator or a motor, does not enter into consideration for the reason that the commutating coils should be connected to oppose the polarity of the armature field in any case, and this test determines directly whether or not they are so connected, as will be seen by consideration of the following facts:

The battery current sets up an armature field whose poles are under the commutating poles. The flux crosses the air gap and threads through the commutating poles, completing the circuit through the yoke and the adjacent commutating poles, as shown in the sketch. The flux thus established in the commutating pole by the current in the armature is opposite in direction to that which is necessary to neutralize the armature field, and therefore its disappearance induces in the coil an e.m.f. that is opposite in direction to that which is required to establish the desired polarity. Thus, if the coils are properly connected, the current due to the induced e.m.f. flows out of the coil to the lead that has been defined as positive, and thence to the positive terminal of the meter, causing positive deflection.

M. J. RICH.
Trenton, N. J.

Device to Determine Motor-Starting Torque

WHEN investigating motor trouble or planning a motor drive it is often necessary to find out the dead load on the motor in horsepower. Some motors (induction and synchronous) cannot start at full load although, once started, they can pull two or three times their rating. Therefore it is advisable to determine the starting effort or "static torque" required. This can be accomplished by means of a pipe wrench, a piece of pipe, a hook and a weight, combined as shown.



Pipe wrench, piece of pipe and weight arranged to measure "static torque"

The weight is gradually increased until the pull effected causes the shaft to start to turn. By noting the horizontal distance in feet from the weight to the center of the shaft on which the wrench is gripped, the weight applied and the normal speed of the shaft, the torque can be calculated. The horsepower required to start the motor from rest will be given by the formula (R.p.m. $\times$ L_{ft} $\times$ 2π $\times$ W_{lb})/33,000.

Contest Which Reduced Armature Repairs in Large Steel Mill

A CONTEST which pitted different operating sections against each other has been very effective in reducing the number of damaged armatures and the time lost in repairing motors in a large steel manufacturing mill. There are two prizes given to the sections of the mill which qualify. The first prize is given for the greatest relative improvement in reducing the number of changes of armatures necessitated by trouble in the electric motors. The second prize is for the greatest improvement in reducing the amount of time lost in different operations by reason of motor trouble. Honorable mention is given to four other sections, respectively for the best standing as regards armature changes, the best standing as regards lost time, the fewest armature changes in the present month and the least time lost in the month.

"Improvement" is based on the gain of the present standing over last month's standing and is expressed in percentage. What is called the "present standing" is based on a comparison of the last three months' operation with the last two years' operation. For instance, the standing as regards armature changes is expressed by equation (2). The top member of the equation expresses the number of armature changes per motor in use per ton of steel produced for the last two years. This is divided by the number of armatures replaced per motor in use per ton of steel produced for the last three months. The total is divided by 10,000 for convenience.

The section of the mill which has the highest value as derived by this equation is said to have the best standing as regards armature changes. The best standing as regards lost time is figured in the same manner. In calculating the "greatest improvement," for which the two prizes are given, the percentage gain in standing of the present month over the standing of last month is figured. The awards are made each month.

This system is well suited for a comparison of the carefulness of operators even in sections which have widely different equipment, functions and working conditions, as it takes into account the number of motors used in each section and the number of tons produced, as well as the performance in the section for the last two years, which is indicative of the kind of service which the motors are performing.

Pittsburgh, Pa. D. W. BLAKESLEE.

Table of awards in contest which reduced number of motor troubles

First Prize.—Greatest improvement in armature changes.
Second Prize.—Greatest improvement in time lost.
Honorable Mention.—(1) Best standing, armature changes; (2) best standing, lost time; (3) fewest armature changes in month; (4) least time lost in month.

$$\text{Improvement} = \frac{\text{Present standing} - \text{Former standing}}{\text{Former standing}} \times 100 \qquad (1)$$

Standing = Comparison of last three months with last two years Armature changes:

$$\text{Standing} = \frac{A_3/M_3T_3}{A_2/M_2T_2} \times \frac{1}{10{,}000} \qquad (2)$$

A_3 = Number armatures changed in last three months.
A_2 = Number armatures changed in last two years.
M_3 = Number motors in use last three months.
M_2 = Number motors in use last two years.
T_3 = Tons produced last three months.
T_2 = Tons produced last two years.

Lost time:

$$\text{Standing} = \frac{t_3/M_3T_3}{t_2/M_2T_2} \times \frac{1}{10{,}000} \qquad (3$$

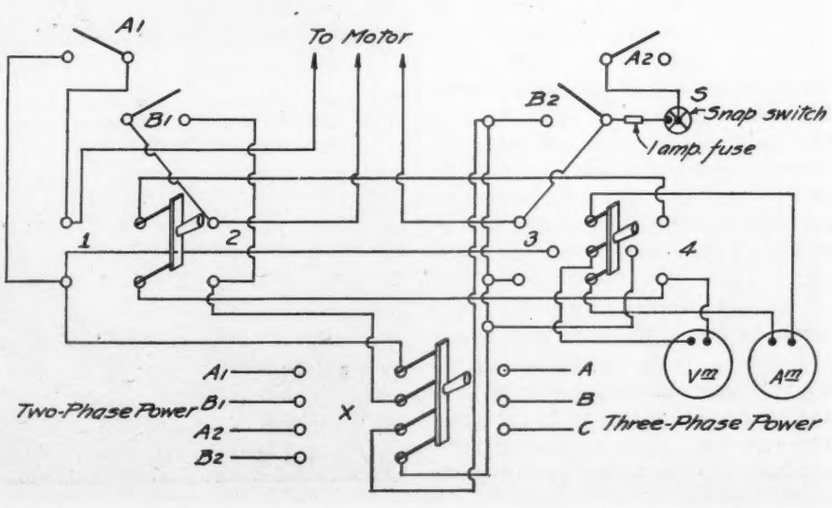
t_3 = Number minutes' delay in last three months.
t_2 = Number minutes' delay in last two years.
Other letters are same as for armature changes above.

Board for Testing Two-Phase, Three-Phase, or Direct-Current Motors

FOR VARIOUS testing jobs in the field a convenient testing board, as shown in the accompanying diagram, has proven useful. The connections as shown are for three-phase-three-wire or two-phase-three-wire work. If a four-wire-two-phase motor is to be tested the line lead A_2 is connected to one side of the switch A_2, the other side of the switch A_2 being connected to the motor. The snap-switch S is closed in order to read the voltage across the line leads A_1 and A_2, this snap-switch connecting switches A_2 and B_2 through a small fuse. With these modifications the operation of the board is the same as for two-phase-three-wire work.

For two-phase-three-wire motor testing work the operation of the board is as follows: Connections are made to the power supply through a switch and starting compensator not shown, (*Continued on page 104.*)

Diagram of board for testing A. C. and D. C. motors



Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

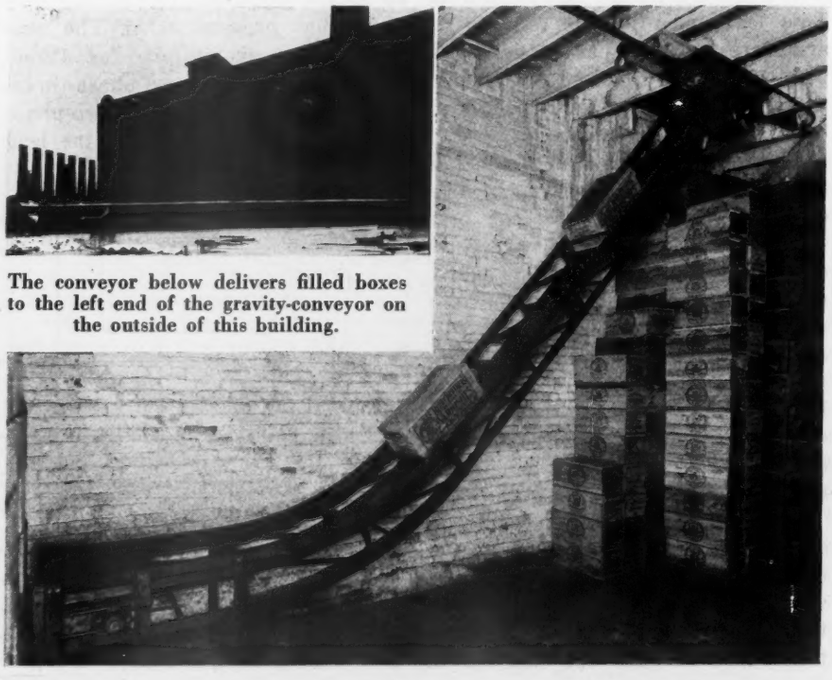
Conveyor Saves Two-Thirds of the Labor Formerly Required to Load a Car of Varnish

BY ADOPTING a simple conveying scheme for handling boxes of paint and varnish from the store room to the car-loading platform, Berry Bros., Detroit, Mich., eliminated a large portion of the labor involved in shipping out the finished product of their plant. The store room is some distance away from the loading platform, and it was formerly the practice to move the outgoing material between these two points by means of a motor truck.

A forty-five degree Dow elevator of the pusher-bar type was finally installed in the storeroom, the lower end being placed near the floor level and the upper end near the ceiling. This conveyor discharges the boxes placed on it onto a roller gravity-conveyor running through the wall and along the outside of a building for about 160 ft. Then the conveyor turns at right angles and passes through another wall and down to the loading platform. Where the conveyor passes along the outside of the building it is supported on brackets attached to the wall and is protected by a corrugated iron housing.

The motor-operated elevating-conveyor in the store room thus raises the loaded boxes high enough to allow them to travel by gravity over the long train of rollers in the gravity-conveyor. Such an arrangement confines all the power-driven parts to a small piece of equipment that is always in sight of the man feeding the conveyor. The use of gravity rolls at the point where a turn is made also reduces the amount of attention required in maintenance of the equipment.

With the original method of transporting the boxes of paint and varnish by a motor truck a total of thirty-six man-hours of labor was required for the handling of each carload of boxes. After the conveyor was placed in service in 1920 the labor required for loading a car was reduced to between ten and fifteen man-hours, a reduction of approximately two-thirds.



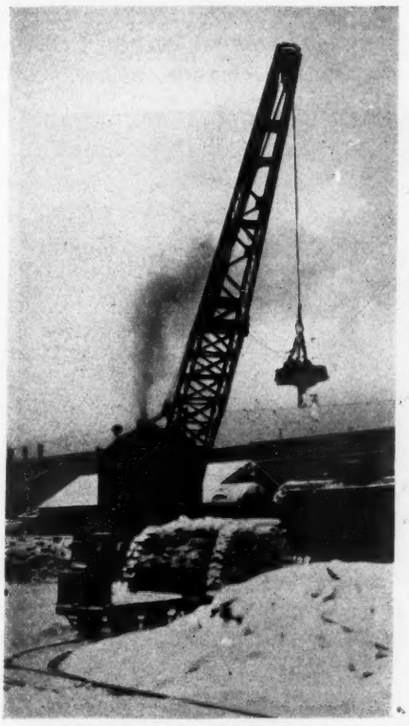
The conveyor below delivers filled boxes to the left end of the gravity-conveyor on the outside of this building.

Locomotive Crane With Electro-Magnet Handles Pig and Scrap Iron Cheaply

PIG iron received in the plant of the Oliver Chilled Plow Works, South Bend, Indiana, is unloaded from the railroad cars by means of a 42-in. electromagnet handled by a locomotive crane. The accompanying illustration shows the equipment in operation, dropping pigs from an open car into a pile on the ground. Three pigs were lifted in the particular operation shown: one pig is still flat against the face of the magnet; one is just ready to fall, and the third pig has already fallen about a foot away from the magnet.

One of the interesting features in connection with this equipment has to do with the method of supplying energy for the magnet. A small engine-driven generator is mounted in the crane cab and supplies the direct-current energy required for magnetization. Such an arrangement makes it convenient to operate the crane at any point about the works and eliminates the need of running direct-current circuits that would be used only for magnet operation. Steam is required on the crane for general operation; so little extra ex-

pense is entailed by the local generation of the needed magnetizing current. In case of an emergency where the generating set on the crane might be out of service it is possible to run a temporary supply line to serve the magnet. In addition to handling pig iron this crane with the magnet also loads and unloads scrap iron, and does such other bulk iron handling work as may be required about the plant yards. A magnet of this size should lift from 500 to 1,500 lbs. of scrap or pig iron at a load, the three pigs lifted in the illustration making a load between these values. In normal operation the plant where this outfit is used handles between 250 and 300 tons of iron per day.



Locomotive crane unloading pig iron from railroad car.

Energy for this magnet is supplied by a small steam-driven generator mounted in the crane cab. This equipment is used to handle scrap and other iron materials at various locations in the plant yard.

Works Engineer,
Oliver Chilled Plow Works, L. B. HORTON.
South Bend, Indiana.

Saving time and labor in the machine shop.

Transporting a heavy punch-press yoke to the other end of the shop takes but a moment with this 15-ton, 60 ft. Pawling & Harnischfeger crane. The two chain slings are attached by the aid of two bars pushed through holes in the yoke, as shown, while the wood blocking and skids serves to hold the yoke in an upright position when placed upon the floor. Note the location of the operator's cab at the side of the bridge, giving a maximum trolley travel at both sides of the span.

Overhead Crane Handles Work and Materials in Machine Shop

EXPERIENCE has shown the overhead crane to be a most economical tool for the general handling of materials in machine shop work. The accompanying illustration shows such a crane of 15-ton capacity in the shop of the Hanna Engineering Works, Chicago, Ill., lifting a yoke for a punch press. This shop manufactures riveters, punches, foundry equipment and similar products, and the crane shown is called upon to do a large amount of lifting and handling in connection with the shop work. Cranes of this type are used to load and unload railroad cars, transfer work in process from one part of the shop to another and in some cases hold up materials while they are being worked upon.

This crane is of the 3-motor type. That is, it has only a single hoist; the other two motors operating the bridge and the trolley. The crane shown has a span of approximately 60 feet; however, spans greater than this can be had, to conform to building design. A standard crane of the type shown is equipped with a 25-hp. hoist motor for a hoisting speed of 18 ft. per min. For a trolley speed of 125 ft. per min. it would be provided with a 6-hp. trolley motor, and for a bridge speed of 300 ft. per min. it would require a 20-hp. motor. For a span of 40 feet the size of the bridge motor would be reduced to 15-hp., and for a span of eighty feet the bridge motor would be 25-hp. in size. Hoisting speeds on standard equipment of this type vary from 23 ft. per min. in units of 5-ton capacity to 8 ft. per min. in units of 60-ton capacity. Motors for these various sizes range respectively from 10 hp. to 50 hp. Trolley speeds vary from 125 to 100 ft. per min. and trolley motors vary from 2 to 15 hp. between the same limits. Bridge speeds vary from 300 to 200 ft. per min., the larger-capacity units having the slower speeds. A 10-hp. motor is used on the bridge of a 5-ton crane with a bridge span of forty feet and a speed of 300 ft. per min. In comparison with this, a 70-hp. motor is used on a 60-ton crane with a span of eighty feet and a bridge travel of approximately 200 ft. per min.

The speeds at which the various elements of a crane can operate are the vital factors in the economy of a crane for quantity material handling. Where the runway is short or where only short bridge travels are required the bridge speed need not be high, but as the length of run increases the bridge speed becomes an important factor in handling capacity.

Also in like manner, the trolley and hoist speeds become important as cross travel or lifting become predominating operating factors. Of course, a crane when once built, cannot be re-equipped for increased capacity unless the original design provided for such alteration. However, when different cranes are available for a given task it is often possible to effect material economies by selecting the unit with the most appropriate speeds for the particular job in hand.

Motor Operated Hoist Saves Labor and Valuable Floor Space

IN ANY plant producing or using a variety of small parts in large quantities the handling and storing of material and finished work is a real problem. The Seng Co., Chicago, Ill., manufacturers of furniture hardware, make many small parts and the handling of the finished and partly finished work formerly constituted a large part of the production problem. Materials and parts were kept in wheeled "tote" boxes having a minimum capacity of 450 lbs. each, these boxes being used both to transport and store the work. A total of 1,360 such boxes were required to handle the plant output, and two men were kept busy shifting them about. Furthermore, a large amount of valuable space was occupied by these boxes of parts, and the congestion was so great that it was extremely difficult to pick out and remove any desired container.

As a solution of the storage problem storage racks, four tiers high, were installed, together with a small, motor-operated hoist running on a track along the front of the racks. The track on which the hoist runs is depressed just enough below the floor level to allow the hoist platform, when lowered, to be on a level with the floor. Thus, it is possible to roll the boxes directly onto the hoist platform on which are a set of wheel guides and a locking device to keep the box in its proper place.

A 2-hp., 220-volt, direct-current motor with an automatic stop is employed to elevate the loaded platform to the proper height, the box being then pushed into place in the rack by hand. Energy is supplied to the motor on the hoist from a pair of overhead trolley wires protected by shields that may be seen in the upper part of one of the illustrations.

This platform hoist solved the problem.

Material storage boxes are now handled with one-half of the labor and in one-third of the space formerly required. As shown, the hoist is ready to discharge a box onto the third tier of the storage rack. An automatic stop working on the motor circuit brings the platform to rest at the proper elevation to discharge the load directly onto the rack. This hoist was made by the Economy Engineering Co., Chicago, Ill.

This method of storing and handling the parts makes it possible for one man to take care of the work, instead of two as formerly. In addition to this saving about two-thirds of the valuable floor space formerly used is now available for other purposes. The space saved is worth all that the installation cost; so that the labor saving is all pure gain.

As a further feature any desired parts are always easily available without moving a great number of boxes and so mixing up the stock. This is a practical point which always needs to be considered when planning a storage system.

Valuable floor space occupied by storage boxes.

This illustration shows how the shop floor in the plant of the Seng Co., Chicago, Ill., looked before tiered storage was adopted. Two men were required to handle the 1,360 boxes used for transporting and storing the parts.

Flexibility of Electric Service

(*Continued from page 75*)

flooring as a protection against vapors. Three-wire 115-230 volt distribution is carried out.

Pilot lamps of 75 watts rating are controlled in general from points just inside the stairway entrances through momentary contact and Palmer solenoid switches located close to the feeder-risers supplying this service. The bridge is lighted by 60-watt lamps mounted in shallow-bowl reflectors 10 ft. 6 in. above the flooring and at each end of the bridge is a switch controlling one circuit or half of the lamps.

List of Motors in new Weaving Building and Raw-stock Dyehouse.

All motors are 550-volt, 60-cycle, 3-phase induction type, except where noted.)

Motors in Weaving Building

No. of Motors	Location	Maker	H. P.	Speed R.P.M.	Machines Driven
6	Basement	Gen. Elect. Co.	50	750	Fans on Carrier system
2			25	1700	Pumps on Carrier system
2			15	1700	Pumps on Carrier system
1		Gen. Elect. Co.	10	1200	Size pumps
1		Allis-Chalmers	7½	1750	Centrifugal pump
1		Gen. Elect. Co.	150	1750	Fire pump
4		Mechanical Appliance Co.	5	1200	Sump pumps
1			3		Drinking water system
1			1		
	First Story				
3		Barber-Coleman	¼ D.C.	5000	Tying-in machine (110 Volts)
2		West. Elect. Co.	½	1000	Drawing-in machine
1		Gen. Elect. Co.	60	900	Slashers
1		"	20	1200	Slasher exhaust fan
1		"	20	1200	Slasher exhaust fan
1		"	15	1200	Slashers
1		"	30	1200	Size mixing
1		"	20	1200	Beamers
1		"	15	1200	Brushers and exhaust fan
1		"	10	900	Sewing machines
1		"	20	1200	Singers, brushes and ex. fan
1		"	15	1200	Tenter fan
1		"	25	1200	Tenter fan
1		"	1	1800	Tenter exhaust fan
1		"	1½	1800	Tenter exhaust fan
6		"	20 D.C.	500–1500	Calenders (220 Volts)
6		"	10 D.C.	600–1800	Tenters (220 Volts)
3		"	15 D.C.	550–1650	Mangles and washers (220 Volts)
4		"	1	1200	Bobbin conveyors
1		"	5	900	Bobbin conveyors
4		"	7½	1200	Exhaust fans
3		"	30	1200	Chain dyeing units
1		"	15	1200	Exhaust fan
1		"	10	1200	Hydro-sulphide plant
	2nd Story				
1728		"	½	1800	Looms—30-inch
	3rd Story				
1692		"	½	1800	Looms—28 and 30-inch
	4th Story				
1620		"	½	1800	Looms—37½ & 43½-in. B.S.
	Miscel.				
2			42		Elevators
2			2		Toilet vents

Motors in Raw Stock Dyehouse

	First Story				
3		Gen Elect. Co.	30	1200	Vacuum dyeing machines
3		"	50	900	Extractors, feeders and fans
1		"	100	900	Feeders, extrac., dyers
4		"	10	1200	Fans for cotton conveying
	2nd Story				
2		"	30	1200	Cotton dryer and fan
1		"	100	900	Cotton dryers and fans
1		"	40	900	Supply fan—ventilating sys.
1		"	30	1200	Exhaust fan—dyeing mach.
1		"	20	1200	Mixing tanks
	3rd Story				
4		"	30	1200	Cotton dryers
1		Allis-Chalmers	30	1200	Cotton dryer
	4th Story				
4		Gen Elect. Co.	20	1200	Cotton conveying system
2		"	30	1200	Cotton conveying system
1					Elevator

List of Largest Items of Material Used

20,190 ft. ½ in. conduit
86,660 ft. ¾ in. conduit
67,180 ft. 1 in. conduit
39,370 ft. 1¼ in. conduit
9,530 ft. 1½ in. conduit
6,480 ft. 2 in. conduit
4,820 ft. 2½ in. conduit
27,480 ft. 3½ in. conduit
3,410 ft. 3 in. conduit
20,015 ft. No. 14 R.C. wire
191,650 ft. No. 12 R.C. wire
111,220 ft. No. 10 R.C. wire
217,188 ft. No. 8 R.C. wire
78,000 ft. No. 6 R.C. wire
83,528 ft. No. 4 R.C. wire
2,000 ft. No. 2 R.C. wire
6,460 ft. No. 1 R.C. wire
4,465 ft. No. 2-0 R.C. wire
14,845 ft. No. 2-0 R.C. wire
5,100 ft. No. 3-0 R.C. wire
7,420 ft. 300,000 circ. mil R.C. wire
8,260 ft. 400,000 circ. mil R.C. wire
2,650 ft. 500,000 circ. mil R.C. wire
86,540 ft. 600,000 circ. mil V.C. wire
4,040 lights equipped with Ivanhoe reflectors
285 Flush switches and receptacles
3 200-kw. transformers, 500 to 115-230 volts
3 100-kw. transformers, 2300 to 600 volts
5,040 ZGC condulets, 3 pole 600 volts
339 3 pole 600-volt non-fused "SQUARE D" switches
15,592 ¾ in. "LB" condulets
1,680 1¼ in. to ¾ in. "T" condulets
3,360 1¼x¾x1¼x¾ in. "X" condulets
5,670 ½ in. inserts
15,120 3-amp., 600-volt fuses
500 60-amp., 600-volt fuses
74 D&W enclosed 3-pole, 30-amp., 600-volt cutouts
21 3½ in. "E" condulets
12 No-Ark 3-pole, 400-amp., 250-volt service boxes
50 36x6x6 in. Unilet pull boxes
1,000 ft. ¼x5-in. bus bar copper
1,575 ft. 500,000 circ. mil V.C. 3 conductor l'd-cov. cable, 600 volt
10,250 ft. 600,000 circ. mil V.C. 3 conductor l'd-cov. cable; 600 volt
5,600 ft. 300,000 circ. mil V.C. 3 conductor l'd-cov. cable; 10,000 volt
1,850 ft. 600,000 circ. mil W.P. single conductor

Lighting Cabinets

8 4-circuit dead-front panels
2 8-circuit dead-front panels
8 10-circuit dead-front panels
8 18-circuit dead-front panels
10 22-circuit dead-front panels
13 24-circuit dead-front panels
4 26-circuit dead-front panels

Power Cabinets

9 10-circuit panels
4 4-circuit panels
4 5-circuit panels

Winding Small Armatures

(*Continued from page 83*)

to the left, the top lead is put in adjacent bar to the left. If these instructions are reversed, the rotation of the motor will be reversed, or if it is a generator, the polarity will be reversed. This would be the result, for instance, if the motor in Fig. 9 were so arranged that the lead *a* was connected to the left of bar 1 instead of to the right.

After the leads are soldered to the commutator, several turns of cord should be taken around the leads near the commutator. This will keep them from flying outward when the machine is in operation.

Layer Winding Used in Automobile Generators

Another type of hand-winding which is used principally in automobile generators of an old type is called layer winding. It is well to know how to put on this winding as it is very useful when the turns in the coil are from 1 to 9, the wire fairly large and the end room scarce. The armature shown in Figs. 10 and 11 has a layer winding. It is for a four-pole machine and is connected up in a wave winding. It will be impossible to put such a winding on an armature if the number of slots and poles and the pitch do not satisfy the following equation: (Number of poles × pitch) + or — 1 = No. of slots. If the sign is —, this will be a progressive winding; if it is +, this will be a retrogressive winding. In Fig. 11 there were four poles and twenty-seven slots; therefore the pitch was 1 and 8, or 7 slots. This makes a progressive winding. Twenty-nine slots would make a retrogressive winding.

Fig. 10—Hand-wound layer winding takes very little end room.

As a usual thing a machine of this kind is wound by inserting previously-formed coils. In this case, however, there was not room and therefore the motor was wound by hand. The number of turns per coil is small and the wire is large. To get the idea of putting on such a winding look at Fig. 11.

The distinguishing feature of this type of winding is that four coils are visible across the end of the armature; also the wires are laid down in layers, the bottom layers being close to the shaft and each succeeding layer being put on further away from the shaft, as shown in Fig. 10.

To start, put several sleeves on the wire, alternating red and white. Start in slot 1, leaving the white sleeve for the starting lead, winding across the back of the armature on the right-hand side of the shaft to and through slot 8, leaving the finishing lead in slot 8 with a red sleeve. In winding the first coil bend it in toward the shaft as shown in Fig. 11. Start the second coil in slot 8, in which the first coil was finished, and wind through this slot and slot 15 in the same manner as the first coil. Continue in this manner with the third and fourth coils, which brings the finish of the fourth coil in slot 2. Coil 5 will start the second layer of the winding in slot 2. The coils of this layer should not be bent as close to the shaft as the coils of the first layer, as shown in Fig. 11. The other coils are put on in the same manner, continuing according to the table shown under Fig. 11. The coils of each succeeding layer are further and further from the shaft.

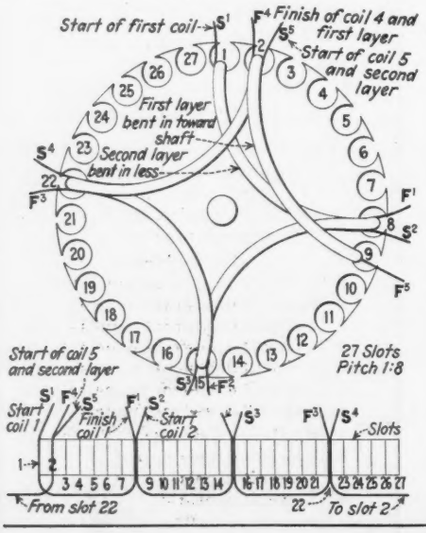
There is a secret in getting the ends of the coils to wind in layers without pounding. This secret is as follows: The first turn across the end of the armature is put in the middle of the space which the complete coil will occupy. Then the following turns are laid on opposite sides alternately; that is, the second turn to the right, third to the left, fourth to the right, and so on. Allow the wires to bunch up in the slots, but start to fan them out as close to the slot ends as possible.

In connecting this type of winding to the commutator, the same method is used as already described for the split and split-loop windings. When connected, this winding forms a four-pole wave winding.

All the windings described in this and the January article can be wound by hand or by winding machines.

Fig. 11—A layer winding is put on in this manner.

This winding is used where the coils have few turns of large wire, but the end room is so scarce that formed coils cannot be inserted. The first layer consists of four coils which step around the armature, the end of the last coil being in the slot next to the start of the first coil. The second layer passes around the armature in the same manner, the coil ends lying on top of the first layer (see Fig. 10). When completed the armature connects into a wave winding. Such a layer winding is possible only when the following equation holds true: (Number poles × pitch) ± 1 = number of slots. In the armature shown this equation is as follows: (4 × 7) — 1 = 27. This is a retrogressive winding. If the sign had been + instead of —, the winding would be progressive. For instance (4 × 7) + 1 = 29 would indicate a progressive winding. The number of layers equals the number of slots divided by the number of poles as 27 ÷ 4 = 7 layers in this case. The following table shows the slots in which the coils are started and finished:


Start of first coil
Finish of coil 4 and first layer
Start of coil 5 and second layer
First layer bent in toward shaft
Second layer bent in less
Start of coil 5 and second layer
27 Slots Pitch 1:8
Start coil 1
Finish coil 1
Start coil 2
Slots
From slot 22
To slot 2

Coil No.	Start in Slot No.	Finish in Slot No.	Layer
1	1	8	
2	8	15	
3	15	22	1
4	22	2	
5	2	9	
6	9	16	
7	16	23	2
8	23	3	
9	3	10	
10	10	17	
11	17	24	3
12	24	4	
13	4	11	
14	11	18	
15	18	25	4
16	25	5	
17	5	12	
18	12	19	
19	19	26	5
20	26	6	
21	6	13	
22	13	20	
23	20	27	6
24	27	7	
25	7	14	
26	14	21	7
27	21	1	

Things That Cause Trouble

(*Continued from page* 66)

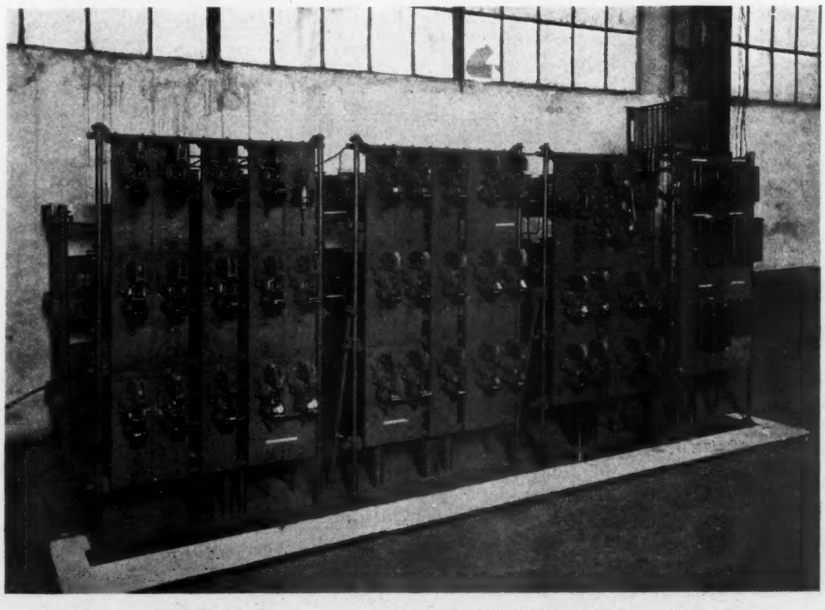
and flushing with water; (5) blowing out the cooling coils with compressed air; (6) re-assembling the electrodes and tubs; (7) adjustment of the electrodes so that they are within an eighth of an inch of touching, and (8) mixing the new electrolyte. The proper density of the electrolyte can best be determined by observing the maximum momentary input to the induction motor at the instant of closing the oil switch when the electrodes are at their maximum separation. This should be approximately equal to the full-load motor rating.

Most of the maintenance on the switchboards and control panels is done during the week by the station operator, but there are always a few mill delays during which odd jobs can be cleaned up. Maintenance on the control panels consists of cleaning and changing contacts and electrical interlocks, adjusting spring tension on relays and magnet switches, tightening connections and general inspection of the operation of the various magnet switches. This general inspection will disclose magnet switches failing to operate, operating sluggishly or operating in wrong sequence. Such conditions may be caused by burned-out coils, grounds, poor adjustment of relays, worn bearings on magnet switches or trouble at the controller. The grid resistors are examined for opens, grounds, loose connections and overheating.

Master controllers can best be inspected during normal operation. The things looked for are worn-out and loose fingers and segments, loose sections of the drum, and undue play in the handle and bevel gear turning the drum.

At the switchboard the exciter-field rheostat is blown out with compressed air quite often, since the carbon dust in the steel mill atmosphere will quickly ground these rheostats. At least four times a year the oil-switches are opened and the contacts inspected and cleaned. On these occasions the oil is usually changed. When it is possible to "kill" the station bus, it is common practice to clean and oil the disconnecting switches, at the same time carefully examining them for evidence of heating.

This switchboard controls a 15,000-hp. reversing rolling mill motor.



Trade Literature
you should know about

Jordan Brothers, Inc., New York City—A booklet describes the various models comprising their line of commutator-truing devices.

E. & B. Manufacturing Company, Detroit, Mich.—A leaflet describes their new "Snap" connector.

The States Company, Hartford, Conn.—Section 10, Catalog 1, covers phasing transformers for reaction component meters; section 12 describes phase sequence indicators.

Mueller Electric Company, Cleveland, Ohio—A new lead-coated wire handle for storage batteries has been recently developed.

Monitor Controller Company, Baltimore, Md.—Bulletin 101, entitled "Starting Small A. C. Motors," describes the Monitor "Thermaload Starter," patents for which are now pending.

The Trumbull Electric Manufacturing Company, Plainville, Conn.—Catalog 12 covers a line of knife and safety switches and wiring devices.

American Electric Company, Chicago, Ill.—Recently issued circulars cover "Dialaphone" intercommunicating telephone systems suitable for operation with magnetos or common battery exchange.

The Automatic Heater Company, Warren, Pa.—The "Sepco" electric glue pot, which automatically maintains the temperature at the proper point, is described in a new folder.

Bussman Manufacturing Company, St. Louis, Mo.—Catalog 11 covers a line of fuses of all types.

The Trumbull Manufacturing Company, Plainville, Conn.—Bulletins 1, 2 and 3 describe live-front and dead-front panel boards, cabinets and switchboard accessories.

The Esterline Company, Indianapolis, Ind.—Bulletin 122 calls attention to the use in industrial plants of the graphic and portable testing instruments made by this company.

The Worthington Pump & Machinery Corporation, 115 Broadway, New York City—Bulletin W-605, entitled "Worthington Instruction Book for Type VH, Class B, BBS, OS, Centrifugal Pumps," is being distributed. It contains 72 pages and gives useful data on the erection and installation of centrifugal pumps.

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.—Leaflet 3443 is being distributed, describing Luminous Top Holder-Socket-Reflectors, which have been designed so as to give a moderate degree of illumination in the space above the fixture.

Sprague Electric Works, 527 West 34th Street, New York City—"GreenfielDuct," conduit rust-proofed by a special process, is described in folder B-3634.

Benjamin Electric Manufacturing Company, Chicago, Ill.—Bulletin 19 illustrates "Ben-ox" interchangeable wiring devices for suspending industrial and commercial lighting units.

Sangamo Electric Company, Springfield, Ill.—Bulletin 59 describes Brooks

Two-Stage Current Transformers, which are designed to effect automatically a correction of current ratio and phase angles between the primary and secondary currents.

Ideal Commutator Dresser Company, Chicago, Ill.—A recent folder describes "Ideal" commutator resurfacers.

Dodge Manufacturing Company, Mishawaka, Ind.—A leaflet describing the "Dodge" pressed steel hanger for general-purpose use has been issued.

The Acme Wire Company, New Haven, Conn.—A general trade catalog has been issued describing "Acme" magnet wire and coil windings.

Federal Porcelain Company, Carey, Ohio—Catalog 2 covers the porcelain knobs, tubes and other porcelain insulating devices manufactured by this company.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—A leaflet describes a small and very shallow rotary canopy switch which has recently been developed.

The Cutter Company, Philadelphia, Pa.—A 36-page U-Re-Lite catalog has been issued by this company describing their enclosed circuit breakers, among which is the new "Auto U-Re-Lite" for the protection of polyphase motors and circuits.

Cote Brothers Manufacturing Corporation, 1548 Tribune Building, Chicago, Ill.—A leaflet describes the new, renewable fuse brought out by this company. It is of the Edison type and is for use on circuits of 125 volts with ratings of 3 amp. to 30 amp.

Jewell Electrical Instrument Company, 1640 Walnut Street, Chicago, Ill.—A pocket memorandum book entitled the "Jot Book" describes a number of the electrical instruments made by this company.

Eck Dynamo & Motor Company, Belleville, N. J.—Bulletins 1300, 1500, 1600 and 1900 describe direct-current motors, back-geared motors and polyphase induction motors, respectively. Bulletin 2201 covers the type "CB" generator.

The Delta-Star Electric Company, Chicago, Ill.—Bulletin 32 describes a complete line of outdoor, high-tension switching and protective equipment of unit type design.

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.—A recent announcement describes the Type "F-11" line of oil circuit-breakers. These are moderate capacity breakers, manually operated, non-automatic and automatic, designed for indoor use.

Valley Electric Company, St. Louis, Mo.—An improved line of electric buffers and grinders is described in a recent folder.

The Triumph Electric Company, Cincinnati, Ohio—A recent announcement describes their "TR" induction motor, which embodies several new features of design.

Westinghouse Electric & Manufacturing Company, 160 Seventh Street, Brooklyn, N. Y.—Booklet 4484 describes a line of meter service switches.

Copper Clad Steel Company, Braddock P. O., Rankin, Pa.—Two leaflets are being distributed, one giving technical data and tables on "Aristos" copper-weld signal wire and the other, technical data and tables on "Aristos" copper-weld wire for series lighting circuits.

Elliott Company, Pittsburgh, Pa.—Bulletin A, 1922 edition, describes a line of strainers for handling water, oil, tar and other liquids.

Chicago Fuse Company, Chicago, Ill.—Catalog 29 has been issued covering their line of fuses, fuse mountings and conduit fittings.

Sprague Electric Works, New York City—Bulletin 48716 describes the Sprague Electric Dynamometer, research type, for the measurement of torque or power.

Economee Rheostatic Switch Company, Philadelphia, Pa.—A booklet describes the "Economee" liquid-resistance, rheostatic switch for use on incandescent lamps and motors. When the switch is thrown in the voltage is slowly brought up to normal.

Wodach Electric Tool Corporation, 23-27 South Jefferson Street, Chicago, Ill.—Announcement is made of a new "Wodach" combination electric drill and grinder. This machine is of the portable type, weighing 18 lbs., and is driven by a ½-hp. motor.

The Allen-Bradley Company, Milwaukee, Wis.—Bulletin E-2910 has recently been issued describing the type E-2910 A.C. or D.C. rheostat designed for general laboratory use.

W. N. Matthews & Brother, Inc., St. Louis, Mo.—A recent folder describes the various models of Matthews Atomatic Spragun and Matthews Atomatic Painting Equipment. These vary in size and capacity from the small models used for very fine work to those employed for painting buildings, bridges and other structures.

Chas. Cory & Son, Inc., 183-187 Varick Street, New York City—In mentioning Bulletin 101-29-A in the January issue, it was stated through mistake that the Corey-Record ohmmeter is used for measuring the resistance of circuits. This instrument is intended for measuring insulation resistances.

Automatic Electric Heater Company, Warren, Pa.—Has prepared a data book giving most complete and concise information on electric water heating, from both technical and commercial standpoints. This company has designed a new 1000-watt Sepco automatic circulation type water heater as the final number of its complete line. The sizes of Sepco heaters now available range from 600-watt "boosters," which may be connected to the lighting circuit, to 3000-watt storage type units.

Board for Test A.C. and D.C. Motors

(*Continued from page* 97)

and the three motor connections are made as indicated. The switches A_1, B_1, B_2, 1, and 4 are closed, switch A_2 not being used. The supply switch is closed and the motor is started up with the compensator or whatever starting device is used. When ready to take the first measurement switch A_1 is opened so that the ammeter indicates the current in phase *A*. With this setting the voltmeter reads the potential across line leads A_1 and A_2 or across phase *A*. Switch A_1 must now be closed and then switch No. 1 can be opened and switch No. 2 closed. Now, when switch B_1 is opened the ammeter indicates the current in phase *B* and the voltmeter indicates the potential across line leads B_1 and B_2, or across phase *B*. The switch B_1 must be closed after reading the ammeter. Since the circuit under consideration is a three-wire circuit, leads A_2 and B_2 are a single conductor, instead of two as shown, and may be connected to either point A_2 or B_2 on the supply switch *X*.

In making a three-phase test the work is started with switches No. 1, 4, A_1, B_1, and B_2 closed. Switch A_1 is opened to allow the ammeter to measure the current in phase *A*. At the same time the voltmeter indicates the potential between line leads *A* and *C*. Switch A_1 must be closed after reading the ammeter, and then switch No. 1 is opened and No. 2 is closed. Switch B_1 may then be opened to measure the current in phase *B*, the voltmeter at the same time indicating the potential between line leads *B* and *C*. Switch B_1 must be closed after reading the ammeters. To take the third reading switch No. 4 is opened and switch No. 3 is closed. Then switch B_2 is opened, the ammeter indicating the current in phase *C* while the voltmeter indicates the potential between line leads *A* and *B*.

A wattmeter can be connected, if desired, with its current coil in series with the ammeter and its potential coil in parallel with the voltmeter. This board can be used for testing direct-current as well as alternating-current apparatus.

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